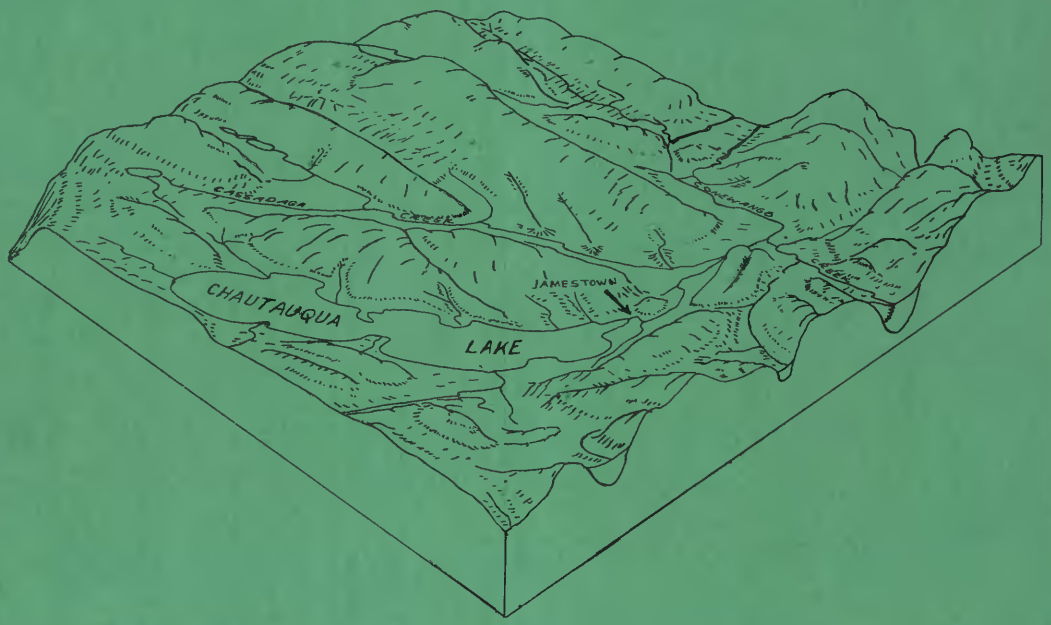
GROUND-WATER RESOURCES OF THE JAMESTOWN AREA, NEW YORK

With Emphasis on the Hydrology of the Major Stream Valleys



By
Leslie J. Crain
U. S. Geological Survey

STATE OF NEW YORK
CONSERVATION DEPARTMENT
WATER RESOURCES COMMISSION

Bulletin 58
1966

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Prepared by
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
in cooperation with

CITY OF JAMESTOWN, and
NEW YORK WATER RESOURCES COMMISSION

STATE OF NEW YORK
CONSERVATION DEPARTMENT
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GROUND-WATER RESOURCES OF THE JAMESTOWN AREA, NEW YORK
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Leslie J. Crain

ABSTRACT

The Jamestown area is in the extreme southwestern part of New York. The area is one of moderate relief and consists of three broad valleys lying between rolling uplands. All of the area except the extreme southeastern corner has been glaciated, and the glacial deposits consist of: (1) a thin veneer of glacial till which overlies the bedrock throughout most of the area, and (2) extensive deposits of glacial outwash, silt and clay, and till which fill the three large valleys to thicknesses of more than 600 feet in places. The bedrock in most of the area consists of Upper Devonian shale, siltstone, and sandstone.

The most productive water-bearing deposits are in the three major valleys and consist of: (1) sand and gravel that either overlies or is interbedded in the silt and clay in the valleys, and (2) sand and gravel as deltas of tributary streams entering the valleys from the uplands. Beds in the lower part of these delta deposits interfinger with the silt and clay that underlies the center of the valleys.

The most important water-bearing deposit in the area is the Jamestown aquifer from which the city of Jamestown draws its water. The aquifer underlies much of the Cassadaga Creek valley and extends eastward into part of the Conewango Creek valley. It consists of a glacial deposit of sand and gravel averaging about 20 feet in thickness which is overlain by silt and clay up to 140 feet thick. The depth to the top of the aquifer is least in the Conewango Creek valley and increases up the Cassadaga Creek valley.

The Jamestown aquifer is hydraulically connected to the lower part of several of the delta deposits in the Cassadaga Creek valley. Before pumping from the aquifer began, water was recharged to the aquifer through these delta deposits and discharged, by slow upward percolation, through the silt and clay confining bed in the central portion of the valley. At that time there was a gradient in the aquifer from north to southeast, and the hydraulic head was above land surface.

The city of Jamestown now (1965) pumps about 6 mgd (million gallons per day) from a well field located in the Cassadaga Creek valley northeast of the city. This pumpage has established a gradient in the aquifer toward the well field from both north and south. The hydraulic head in the aquifer is now

depressed below the land surface except in the northern reaches of the Cassadaga Creek valley and in certain other areas during the spring of the year. About 90 percent of the water pumped by the city is derived from that portion of the aquifer north of the well field. Water in this part of the aquifer is recharged through the delta deposits. This recharge is derived both from precipitation on the deltas and from infiltration of water from the streams crossing them. When recharge from these sources is inadequate, water is drawn from storage in the deltas.

The maximum perennial yield of the Jamestown well field depends on the amount of water stored in the delta deposits and the gradient available to deliver the water to the well field. On the basis of records of water levels in the aquifer and of pumpage, the maximum perennial yield of the well field without dewatering the aquifer is estimated to be about 10 mgd. The limiting factor in the yield of the well field is the amount of water which can be derived from storage in the deltas during the summer season. The maximum perennial yield might be increased by constructing surface reservoirs on the tributary streams to store excess streamflow during the spring and release it to recharge the deltas during the summer. Also, additional water may be available from the northern part of the aquifer if supply wells are constructed in the areas little affected by the present field.

Another important aquifer underlies the Conewango Creek valley near Poland Center. This aquifer consists of a deposit of sand and gravel underlying the silt and clay near the center of the valley. The permeability of the aquifer is about 17,000 gallons per day per foot. The deposit is near the easternmost extension of the Jamestown aquifer but apparently is not connected to it. The aquifer near Poland Center appears to be hydraulically connected with Conewango Creek and may have a potential yield of a few million gallons per day.

Water found in shallow unconsolidated deposits throughout the Jamestown area is generally moderately hard and low in chloride content. The water obtained from deeper unconsolidated deposits and bedrock underlying the valley bottoms may be highly mineralized and contain hydrogen sulfide or natural gas.

At present (1965) about 10.5 mgd of ground water is pumped in the area, and public supplies account for about 7.5 and industries 1.5 million gallons of this total. Because many of the water-bearing deposits in the valleys have been only slightly developed, this total probably can be increased substantially.

INTRODUCTION

Ground water is the most important source of water in the Jamestown area. Most public, industrial, and private water supplies utilize ground water because of its general availability throughout the area, and because it requires little if any treatment prior to use.

Realizing the present importance of ground-water supplies to the area, and that dependence upon and utilization of these supplies will undoubtedly increase in the future, the city of Jamestown entered into a cooperative agreement with the U.S. Geological Survey in 1960 for a study of the ground-water resources of the area.

PURPOSE AND SCOPE OF INVESTIGATION

The purposes of the investigation were to determine (1) the geologic and hydrologic conditions which control the occurrence of ground water in the area; (2) the availability and quality of the ground water, especially in regard to its suitability for domestic, municipal, and industrial uses; (3) the maximum perennial yield of ground water at the Jamestown well field; and (4) the areas in which large ground-water supplies may be developed in the future.

The field phase of the project was conducted during the years of 1960-63 and consisted of:

(1) The collection of data on location, depth, diameter, and water-bearing material of wells, test holes, and springs.

(2) Field examination of bedrock and surficial deposits to ascertain their water-bearing characteristics.

(3) A program of test drilling carried out during the summers of 1961 and 1963.

(4) The collection and analysis of water samples from wells and springs.

(5) The evaluation of aquifer characteristics by means of pumping tests and long-term pumpage records.

(6) The observation of water-level fluctuations in several selected wells.

(7) The measurement of stream discharges at approximately 100 sites in the area.

Field work and data collection were concentrated in the major valley areas. There are sound reasons for this approach. Previous hydrologic investigations in other parts of New York State, with similar geologic and climatic conditions, have established that yields of individual wells in the upland deposits are usually in the range of 10 gpm (gallons per minute) or less. Data collected in the uplands of the Jamestown area have shown that similar conditions also exist there. Tables in this report include records of more than 750 wells, test borings, and springs, and chemical analyses of more than 110 ground-water samples. Graphical logs for more than 250 wells and test borings are shown.

The field work and preparation of this report were under the direct supervision of Ralph C. Heath, district chief.

LOCATION AND EXTENT OF AREA

The area covered in this report is in the extreme southwestern part of New York as shown in figure 1. It encompasses parts of Chautauqua and Cattaraugus Counties. It lies entirely within the area bounded by 79°00' and 79°30' west longitude, and 42°00' and 42°25' north latitude. There are approximately 580 square miles included in the report area.

WELL-AND SPRING-LOCATION SYSTEM

The wells and springs cited in this report are numbered on the basis of a geographic-grid (latitude-longitude) system. The area has been divided into quadrangles with a grid of lines of latitude and longitude spaced 1 minute apart. Each well and spring is designated by a composite of three numbers: first, the digits of latitude, such as 210 for 42°10' (omitting the number "4"); second, the digits of longitude, such as 902 for 79°02' (omitting the number "7"); and third, the number assigned to the well or spring within the 1-minute quadrangle. The complete well number of the first well listed within the 1-minute quadrangle described above would be 210-902-1, as shown in figure 2. A spring number is the same as a well number except that the suffix "Sp" is added, such as 209-903-1Sp.

On the well- and spring-location maps in this report (pls. 1 and 2) the last three digits of latitude and longitude are shown along the margin of the maps and only the number of the well or spring within each 1-minute quadrangle is shown.

ACKNOWLEDGMENTS

Numerous individuals and organizations contributed to the success of the study by assisting in the collection of data and in providing background information.

Employees of the Geological Survey who aided materially in the collection of field data include Richard A. Wilkens, geologist, and Roy Campbell, hydraulic engineer.

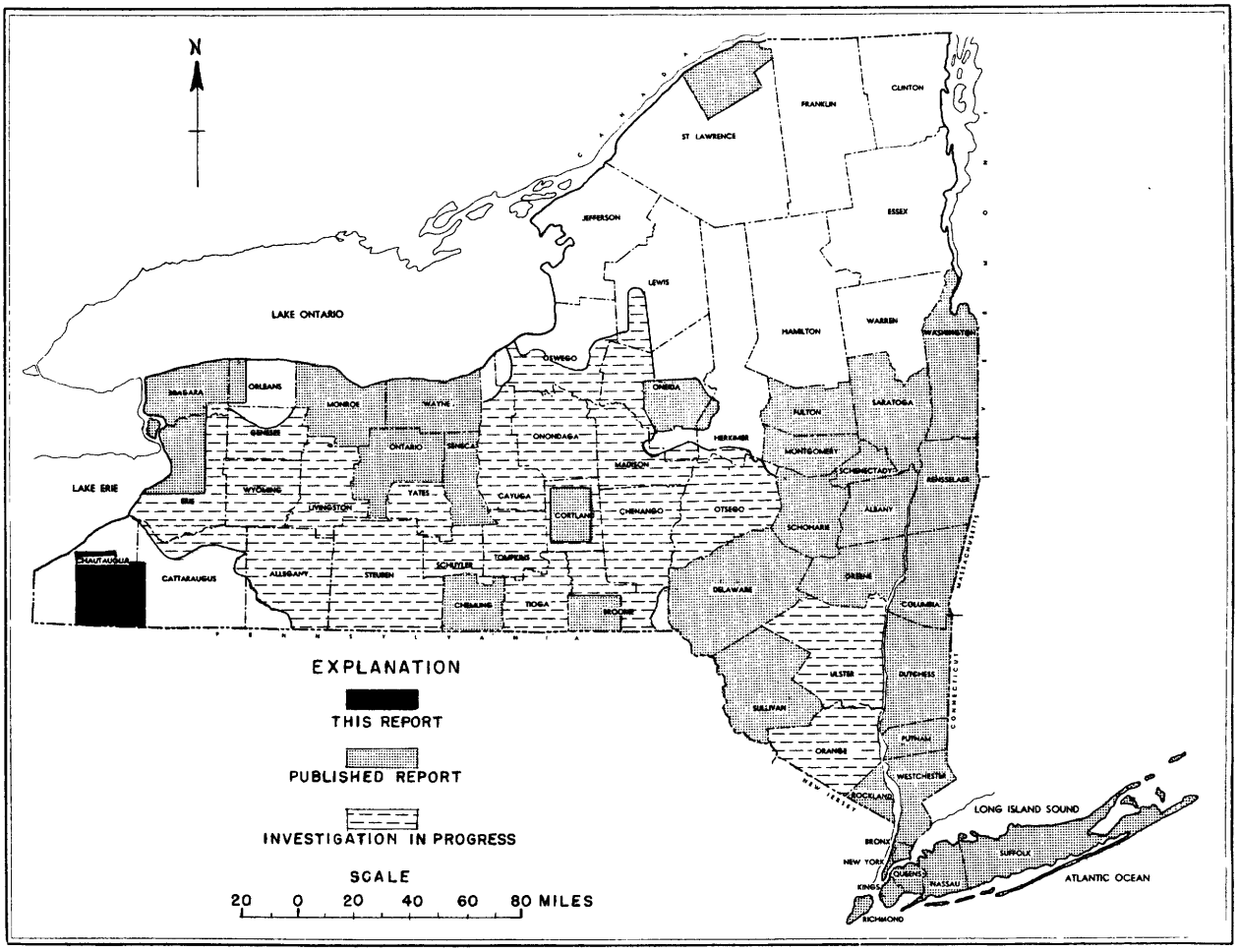


Figure 1.--Location of the Jamestown area, and the status of ground-water investigations in New York. (See list of published bulletins at end of this report.)

Mr. Merle W. Smedberg, superintendent of Public Utilities, Jamestown, provided pumpage and other data on the present Jamestown well field and other records collected by the city of Jamestown. Mr. Richard W. Cooper, senior engineer, Jamestown Pumping Station, assisted in the installation and operation of recording gages on water-level observation wells. Mr. Robert Page, mayor of Cassadaga, and Mr. Charles Cleland, water superintendent, supplied data on the Cassadaga well field and assisted in a pumping test. Mr. George Guild, water superintendent, Frewsburg, assisted in a pumping test and also supplied much useful data on the test drilling conducted by the village. Mr. James Dudley, superintendent of Public Works, Mayville, assisted in conducting a pumping test on the village wells. Mr. Thomas McKenna of Higgins and Sons Construction Company, Buffalo, loaned a high-capacity pump for use on the Poland Center pumping test and incurred considerable expense in installing and removing the pump.

Mr. William Brodie, district soils engineer, New York State Department of Public Works, Bureau of Soil Mechanics, Hamburg, provided drilling logs and ground-water levels for many test borings made in the area by that agency. Among the well-drilling contractors who gave invaluable data on water wells are Layne-New York Company, Inc., Messrs. Elliot Schermerhorn, Howard Cranston, Halley Smith, Arthur Waite, Claude Taylor, Roy Dawley, C. F. Corbitt, and Robert Ehmke.

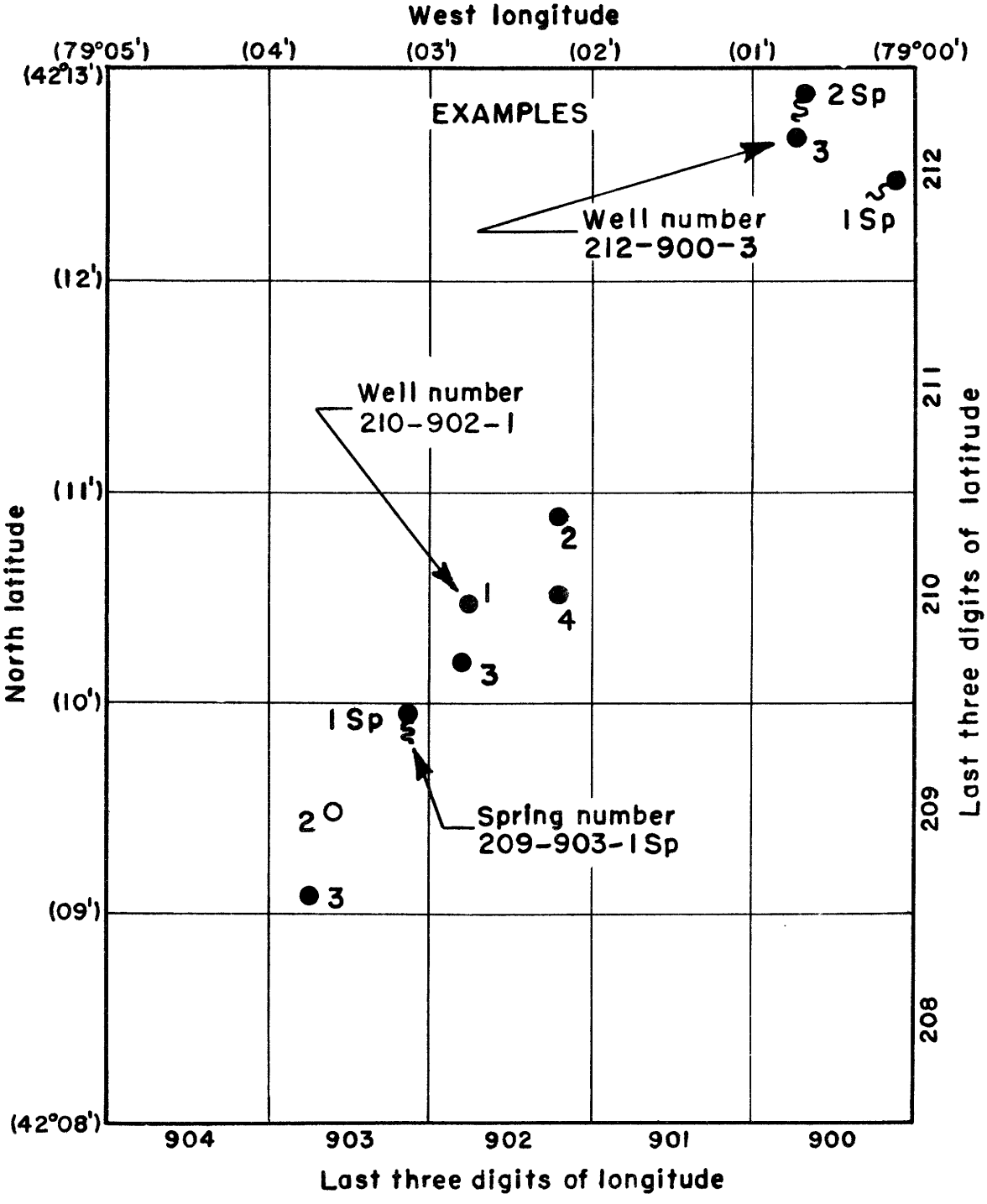


Figure 2.--Well- and spring-location system.

Dr. John G. Broughton, state geologist, and Dr. Ernest H. Muller, professor of geology, Syracuse University, permitted the use of advance copies of Dr. Muller's maps and manuscript on the glacial geology of Chautauqua County.

Mr. Robert M. Howard, superintendent of highways, Chautauqua County, permitted the construction of test wells along county-owned roads and assisted in the collection of streamflow data. State and town officials who aided materially in the test-drilling program include Mr. Stanley Orser, resident engineer, New York State Department of Public Works, Mayville; Mr. J. M. Powers, resident engineer, New York State Department of Public Works, Salamanca; Mr. Carl G. Maier, superintendent of highways, Cattaraugus County; and Messrs. Roger Anderson, Ellington; Harold Carlson, Busti; Arthur Cowen, Conewango; George Dieter, Stockton; Harold Ericsson, Poland; James McIntyre, Gerry; and David Sturges, Harmony.

Finally, much gratitude is due to the residents and industry officials of the area who permitted access to their property and gave information concerning their water supplies.

WATER SITUATION IN THE JAMESTOWN AREA

GROUND-WATER SUPPLIES

Fifteen communities are supplied by thirteen public water supply systems in the report area. Of these systems, ten obtain water from ground-water sources. The locations of the sources of all public water supplies are shown in figure 3.

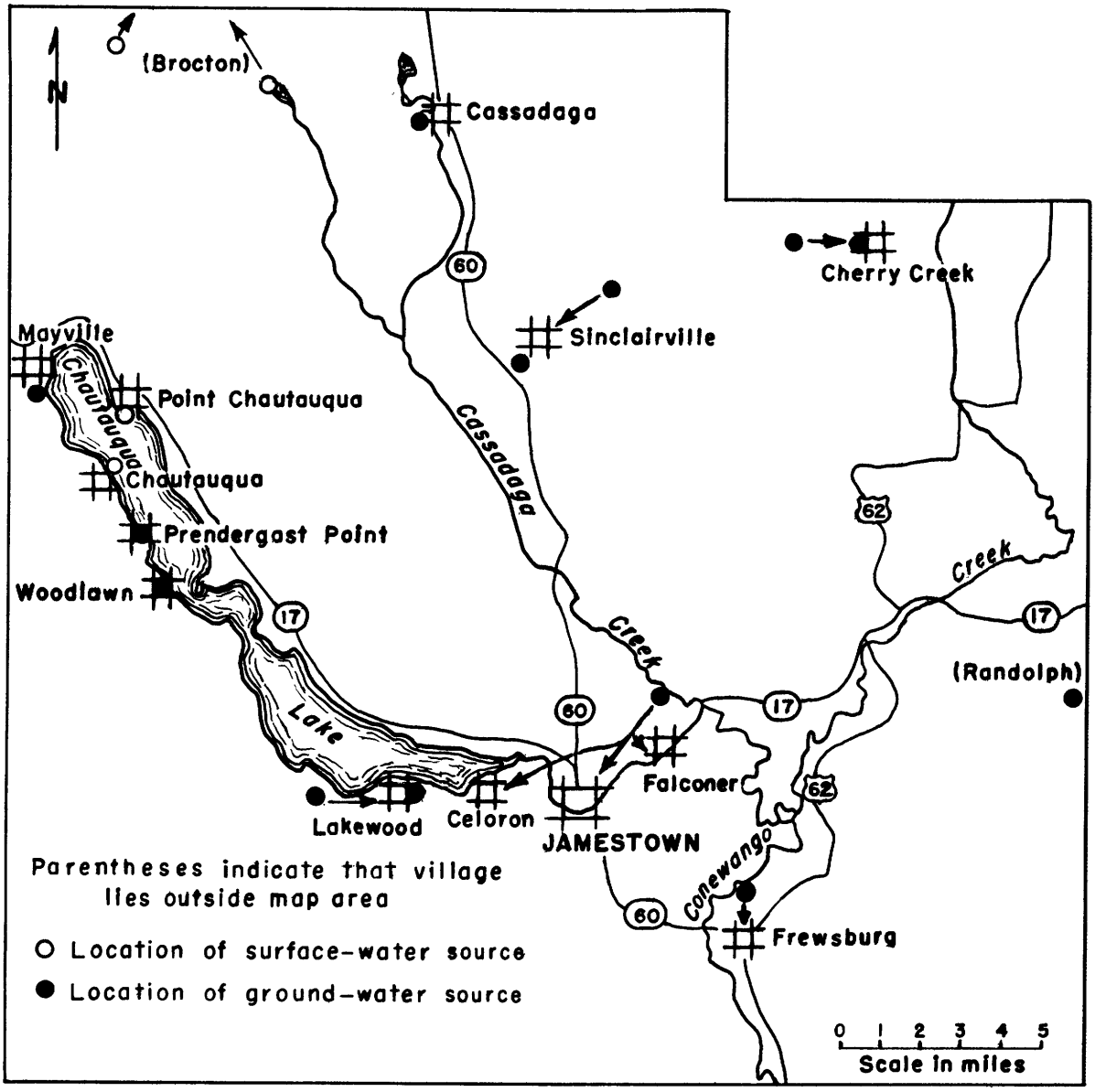


Figure 3.--Communities served by public water supplies, and the location and type of the source.

The city of Jamestown is the largest single consumer of ground water in the area of investigation, accounting for over half the total pumpage. Average pumpage by the Jamestown system is nearly 6 mgd. This pumpage includes water supplied by the Jamestown system to the villages of Celoron and Falconer.

The villages of Lakewood, Mayville, Cassadaga, Sinclairville, Frewsburg, and Cherry Creek all utilize ground water. Although the village of Randolph is located immediately to the east of the report area, its well field is located in the report area. Two smaller ground-water supplies owned by the Prendergast Point Association and the Woodlawn Water District are located along Chautauqua Lake.

Many of the large industries in the area also obtain water from wells, and individual use ranges from a few hundred to hundreds of thousands of gallons per day. Several of these industries also use surface-water sources and water from public supplies to supplement their own systems.

Almost the entire rural population of the area utilizes ground water as a source of supply. Although the individual usage is not large, the total usage is substantial. Table 1 shows the estimated daily pumpage of ground water in the area in 1960. The total amount used at that time was approximately 10.5 mgd, with the city of Jamestown accounting for over half of this total.

Table 1.--Estimated daily pumpage of ground water in the Jamestown area in 1960

Source	Population served 1/ (1960)	Use in gallons per day 2/
Public supplies	62,000	7,500,000
Individual supplies	25,000	1,500,000
Industrial supplies	---	1,500,000

1/ Estimated from 1960 U.S. Bureau of the Census figures.

2/ Figures obtained from N. Y. State Health Dept., estimates by owners, and computations based on population.

SURFACE-WATER SUPPLIES

Three communities have surface-water supplies in the report area. Chautauqua and Point Chautauqua both obtain their water from Chautauqua Lake. The village of Brocton is north of the report area but has a reservoir located on Slippery Rock Creek, northwest of Bear Lake, and a pipeline to Bear Lake for an auxiliary supply. The locations of these supplies are shown in figure 3.

WATER PROBLEMS

The city of Jamestown has experienced a steadily rising rate of water consumption since 1935 as shown in figure 4, coupled with a gradual lowering of water level at its well field. The increasingly lower pumping levels during summer periods have caused the city to become concerned about the adequacy of its supply and to impose restrictions on the use of water.

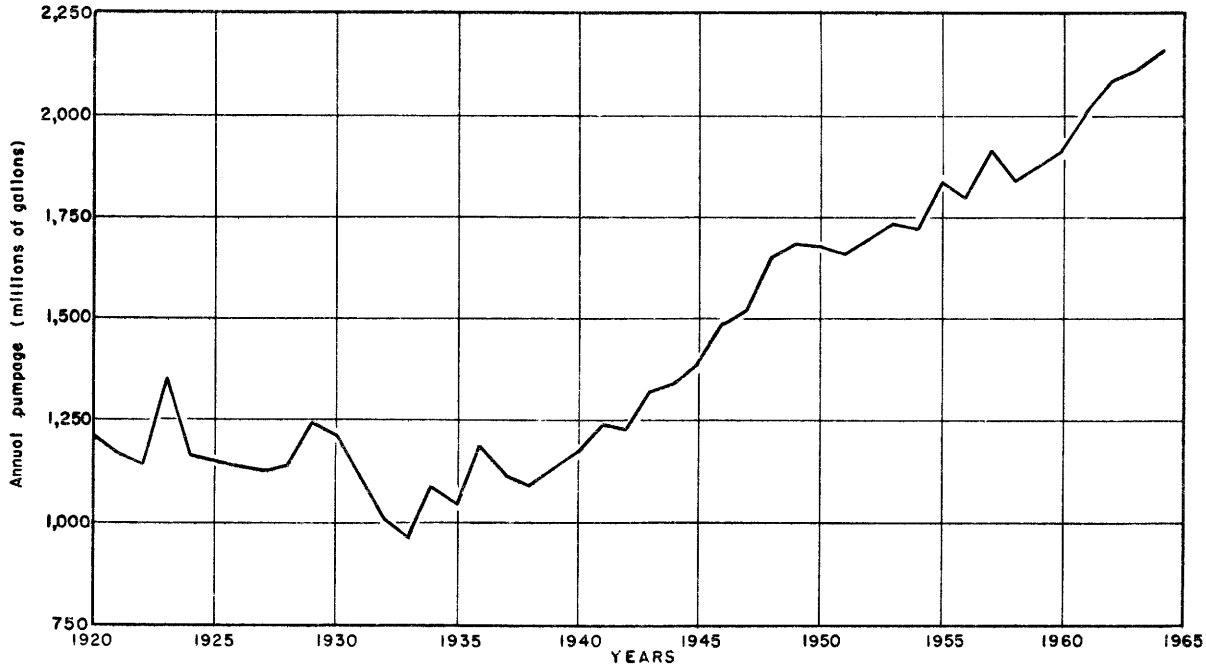


Figure 4.--Annual pumpage at the Jamestown well field.

Many industrial and domestic water supplies are reported to be inadequate during the summer. Because many of the domestic wells had been adequate for years, much of the problem appears to be linked to an increased per capita use of water. One of the principal causes of the increasing demand for water appears to be the rapid growth, in numbers and use, of water-using appliances in the home.

As people have moved to the suburban areas many homeowners have experienced difficulty in locating adequate water supplies. In other localities many homeowners are using highly mineralized water because more suitable supplies could not be found.

The intent of this report is to explore these problems and to determine whether present ground-water supplies are being depleted, how serious and widespread is the problem of poor quality water, and whether ground-water resources, as yet undeveloped, will be sufficient to meet future needs.

GEOGRAPHIC SETTING OF THE AREA

TOPOGRAPHY AND DRAINAGE

Ground water occurs in rocks, and in New York the character of the rocks underlying an area is reflected to a remarkable degree by the topography. Therefore, it is worthwhile to comment briefly on the broad scale topographic (physical) features of the Jamestown area. The outstanding physical features of the area are broad, flat-bottomed valleys separated by areally extensive uplands. The major topographic features are shown in figure 5.

The uplands are rolling, irregular-shaped hills that rise about 700 feet above the valley floors. They are dissected by many narrow, steep-sided valleys containing swift-flowing streams. The region in the extreme southeastern corner is entirely different from the remainder of the area consisting of high, steep-sided hills and very deep and steep-sided valleys. The northwestern corner of the area includes an escarpment which has a maximum altitude of about 1,500 feet above mean sea level. The escarpment drops away quite sharply, toward the northwest, to the lowlands along Lake Erie at an altitude of about 650 feet. Lake Erie, which lies about 1 mile to the northwest of the area shown in figure 5, stands at an altitude of about 570 feet. The lowest altitude in the report area, south of the escarpment, is about 1,230 feet where the Conewango Creek valley crosses the southern boundary. The highest altitude is slightly over 2,100 feet in the hills in the southeastern corner.

The drainage of Conewango Creek, Cassadaga Creek, and Chautauqua Lake is southward into the Allegheny-Ohio-Mississippi River system. The escarpment along the northwestern part of the area separates this drainage from the Lake Erie-St. Lawrence River system to the north. The Conewango and Cassadaga Creek valleys are remarkably flat bottomed and the streams draining the valleys have exceptionally low gradients. For most of its length, Cassadaga Creek has a fall of less than 2 feet per mile, and the fall of Conewango Creek is similar. The gradient of Conewango Creek in the northern part of its valley is much less than 2 feet per mile requiring the construction of a drainage ditch to supplement the natural drainage. (See plate 2.) These low gradients cause both of the creeks to meander back and forth across the valley bottoms.

The Chautauqua Lake valley contains the lake itself and several low-lying areas along the shore. The lake is very shallow and flat bottomed, especially in the southern half. The Chadakoin River is the outlet of Chautauqua Lake, and where it flows through the city of Jamestown it falls approximately 50 feet in 3 miles.

A few minor valleys are similar in appearance to the larger valleys in that they are flat bottomed and contain streams with low gradients. Examples are the valley of Stillwater Creek and the valley running south-westward from Chautauqua Lake.

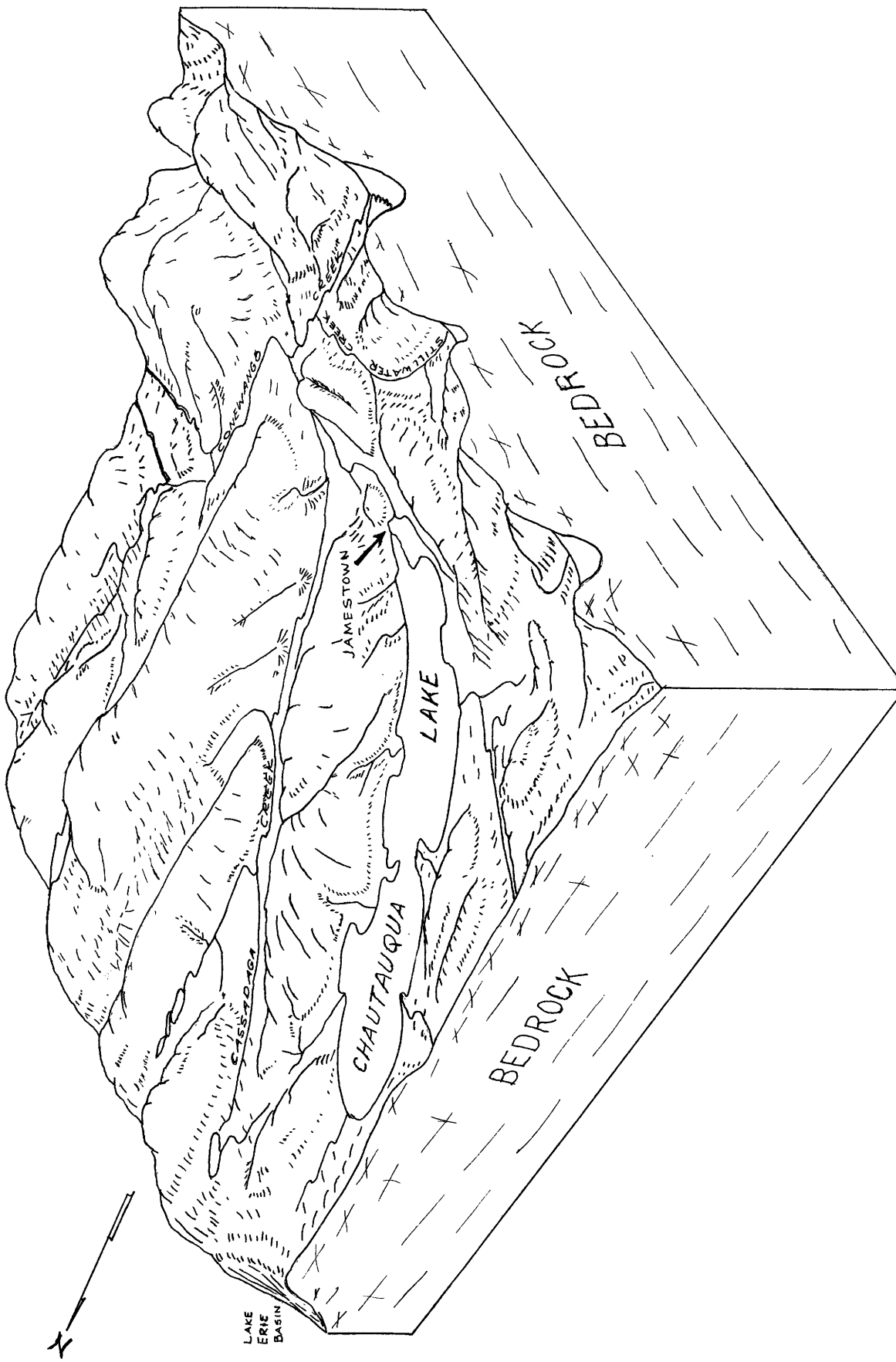


Figure 5.--Topographic features of the Jamestown area.

CULTURE

The population of the Jamestown area is approximately 87,000 (U.S. Bureau of the Census, 1960). About 50,000 persons live in urban areas, all concentrated in and around the city of Jamestown, and another 15,000 live in rural non-farm areas (villages and hamlets of less than 2,000 persons). The remainder of some 22,000 people live in rural farm areas.

The most important industries, which are mainly concentrated in the vicinity of Jamestown, are engaged in the manufacturing of finished wood and metal products. Proximity to extensive hardwood forests makes Jamestown a center of furniture manufacturing. Other important industries are the manufacturing of tools, machine parts, electrical appliances, and metal furniture.

Dairy farming is the most important agricultural activity. Small truck-farming enterprises are located in the Conewango Creek and Chadakoin River valleys.

Tourism has long been of importance to the economy of the region. Chautauqua Institution at Chautauqua, which conducts concerts and lectures during the summer, attracts thousands of visitors. Large summer colonies have developed around Chautauqua Lake. Other parts of the area share in this business to a lesser degree.

Most highway transportation in the area is carried by N.Y. Route 17, the principal east-west highway, and Routes N.Y. 60 and U.S. 62, which handle north-south traffic. The Erie Railroad runs east-west through the area and the New York Central Railroad follows a north-south route. All of these transportation systems follow the major valleys.

GEOLOGIC FRAMEWORK OF THE AREA

Because ground water occurs in rocks, an understanding of its occurrence and availability requires first an understanding of the rocks underlying the area. The water-bearing rocks of the Jamestown area may be divided into two principal types: (1) the consolidated rocks, or bedrock, and (2) the unconsolidated deposits which nearly everywhere overlie the bedrock.

CONSOLIDATED ROCKS

OCCURRENCE AND HISTORY

The uppermost bedrock formations that underlie the area, which together are more than 2,000 feet thick, are composed predominantly of gray shales with some interbedded siltstones and a few beds of sandstone and conglomerate. The formation of these rocks began with the deposition of layers of clay, silt, and fine sand and gravel in shallow seas during the later part of the Devonian Period of Earth history, approximately 350 million years ago. Younger sediments were continually deposited upon older sediments until immense thicknesses accumulated. It is not known how long deposition continued after the Devonian Period, but eventually the sediments became consolidated into the shales, siltstones, and sandstones that are observed in the area today. The bedrock dips gently to the south at a rate of about 50 feet per mile. Thus, from north to south through the area, progressively younger bedrock is found near the surface. All of the bedrock younger than Late Devonian, if any great amount ever existed, has been eroded. The bedrock of the area has been divided by geologists into several formations according to age, character, and area of occurrence. These formations are shown on the Geologic Map of New York State (Fisher and others, 1962).

The Devonian rocks in the Jamestown area are underlain by a sequence of older sedimentary rocks more than 8,000 feet thick. These are, in turn, underlain by crystalline rocks more than a billion years old. None of the rocks older than the Devonian are ever penetrated by water wells.

PHYSICAL CHARACTERISTICS

The bedrock is composed of countless layers or beds which vary in thickness from a fraction of an inch to several inches. Minute tabular openings develop along the planes separating the different beds (bedding planes), which cause the bedrock to separate into definite sheets when exposed at the surface. The bedrock also contains vertical fractures or joints. These joints may extend for distances of a few feet to several hundred feet in both length and depth, and most of them are perpendicular

to the bedding, or nearly so. The openings along these joints are also very minute and tabular, being largest near the land surface and becoming increasingly smaller with depth as the pressure caused by the weight of the bedrock increases.

Beds of conglomerate, which consist of layers of polished, white, quartz pebbles imbedded in a dense, dark-colored matrix of shale or siltstone, occur near the hilltops in the southern part of the area. Bedding is poorly developed in the conglomerate. However, in an exposure near Panama, the conglomerate is separated into large house-sized blocks. The separation of these blocks is due to weathering along joints and a gradual creeping down the steep slopes under the influence of gravity.

In the uplands the bedrock surface is generally found at a depth of less than 25 feet below land surface. However, in the larger valley areas the depth to bedrock often ranges from 200 to 600 feet, or more, below land surface. The relief of the surface of the bedrock is, therefore, much greater than that of the present land surface.

UNCONSOLIDATED DEPOSITS

Most of the unconsolidated deposits in the area differ widely in physical and water-bearing characteristics. Because these deposits are extremely important to the ground-water resources of the area, and may seem to occur in a random fashion, a discussion of the history of their formation will be helpful in understanding: (1) how they were formed; (2) why they are located in their present positions; and (3) why the surface of the area appears as it does today. The lithology and distribution of these deposits are shown in plates 1 and 2.

GLACIAL HISTORY

Beginning about 1,000,000 years ago the climate of the northern hemisphere became considerably colder than it is today. This change in climate resulted in the formation of a huge ice sheet a few thousand feet thick, in eastern Canada, which through a period of several thousand years advanced into the northeastern United States. Whether this particular ice sheet advanced into the Jamestown area is not known. A gradual warming of the climate resulted in melting of the ice sheet. At least three more cold cycles, each producing similar ice sheets, succeeded the first. As each of these sheets advanced it acted in much the same way as a bulldozer. Thus, we see today in the Jamestown area, the effect of only the last ice sheet. This sheet covered all of the area except the higher hills in the southeastern part. Therefore, we are concerned primarily with the glacial deposits of only the last major ice advance in the area.

The principal events in the glacial history of the area are shown in figure 6. Figure 6a shows the area as it probably looked just prior to the first ice invasion. The major valleys of the region were in existence, and the preglacial Allegheny River flowed northward through what is now the upper Conewango Creek valley and into the area now occupied by Lake Erie (Muller, 1963, p. 31). Cassadaga Creek and the streams draining the lower part of the

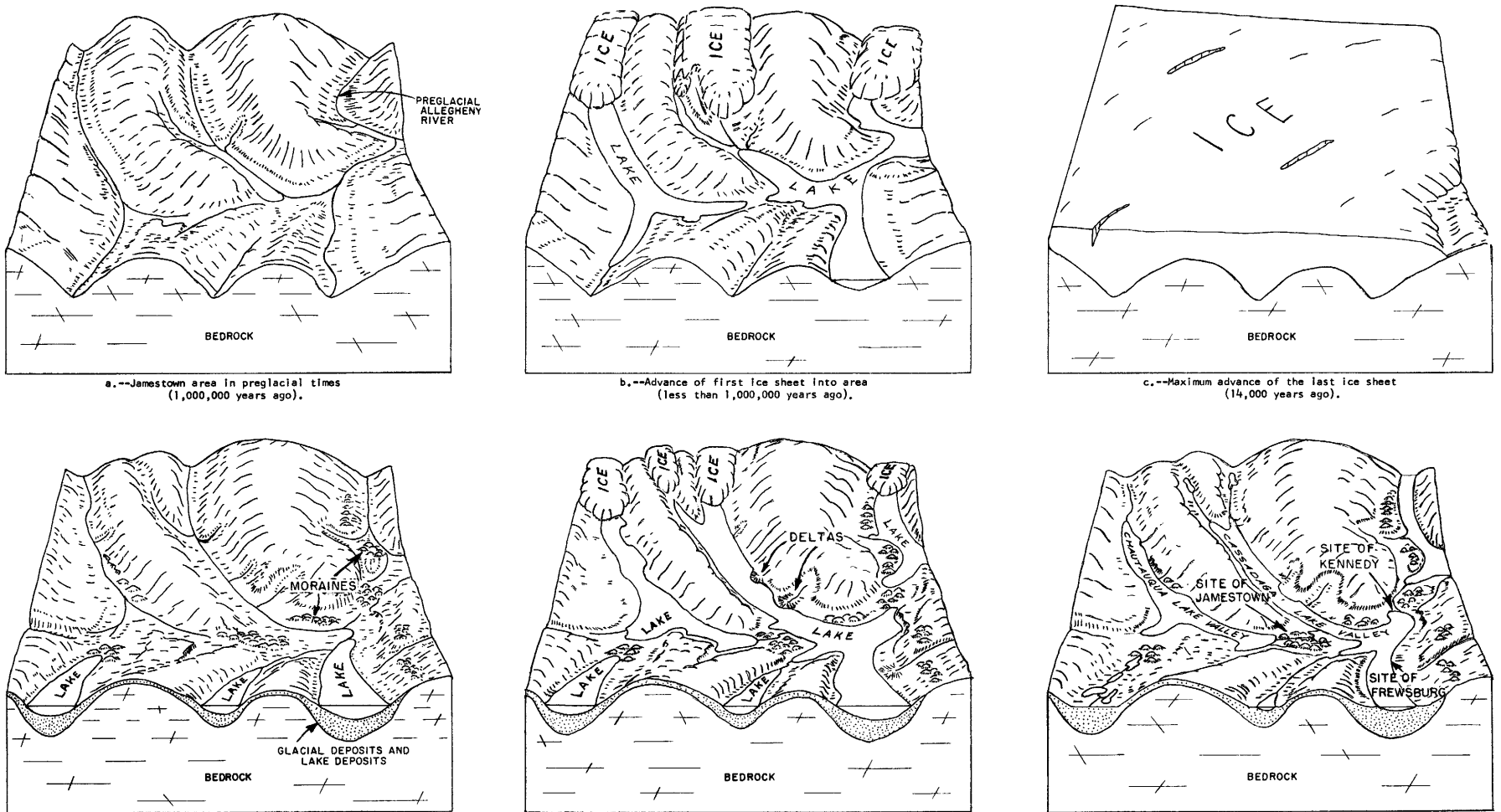


Figure 6.--Glacial history of the Jamestown area.

Conewango valley are believed to have joined and flowed northeastward into the old Allegheny River. The stream draining the valley now occupied by Chautauqua Lake may have flowed northward.

Figure 6b shows the area as the ice sheet began its advance. The main direction of ice movement was from the northwest and tongues of ice following the paths of least resistance moved into the major valleys ahead of the main ice sheet. During this phase the alluvial material in the valleys was shoved ahead of the ice and the bedrock eroded. As the ice blocked the north-flowing streams, lakes were formed. The preglacial Allegheny River, blocked on the north, eventually overflowed to the south and formed its present channel.

Gradually, the main ice sheet covered the entire area except for the higher hills in the southeast corner (fig. 6c). This ice sheet eventually melted back from the area but may have been followed by as many as three more major ice advances and retreats. Long periods of time existed between the major ice advances as the climate warmed and then later cooled prior to the next major advance. As each ice sheet moved over the area it scoured away huge amounts of surficial material and bedrock from the hills and valleys and carried it along. The hills over which the ice had moved were left with smooth, rounded sides and the bedrock valleys were deepened and widened. As each ice sheet melted, it left glacial deposits covering the area and partially filling the valleys. An unsorted mixture of rock fragments termed glacial till was deposited beneath the ice during advancing stages. Lakes formed by the impoundment of the ice were partially filled by the deposition of fine sand, silt, and clay.

The last major ice sheet advanced over the area and again covered all except the southeast corner. This ice sheet also scoured and carried much material along with it, but it also overrode some of the previous glacial deposits in the larger valleys. Along the line marking the maximum ice advance, moraines or large irregular ridges of glacial deposits were formed from the material being pushed ahead of the ice. The ice reached its maximum extent as shown in figure 6c, and began a general retreat from the area approximately 14,000 years ago (Muller, 1963, p. 14). This retreat was not continuous, but involved a series of minor re-advances and retreats resulting in an overall recession of the ice. During this retreat, lakes were impounded in all the valleys in front of the ice sheet. Sand and gravel were deposited in the valleys by south-flowing water released as the ice melted. Silt and clay was also deposited in the lakes.

Finally, the ice melted back out of the area and into what is presently the Lake Erie basin. If the ice withdrew back far enough so that water impounded in front of the ice sheet could escape laterally, the area probably looked very similar to that as shown in figure 6d. Drainage in the major valleys would have been to the north due to terminal moraines blocking the southern parts of the valleys. It is possible that the ice sheet only withdrew a short distance into the Lake Erie basin during this period, and that lakes were maintained continuously in front of the ice sheet and into the valleys. Regardless of the exact sequence of events during this period, the time that elapsed during complete withdrawal of the ice sheet was undoubtedly very short.

Subsequent to the melting of the last ice sheet in the Jamestown area, a minor re-advance soon occurred, but the main ice sheet did not move out of the Lake Erie basin. As shown in figure 6e, it blocked the northern parts of the larger valleys with morainic material, supplied melt water to help breach the southern morainic dams, and turned their drainage permanently southward. Approximately 12,000 years ago (Muller, 1963, p. 48) this ice began to melt back to the north, out of the Lake Erie basin, and eventually melted from both the United States and Canada.

As shown in figure 6f, lakes were left in all three of the valleys. Chautauqua Lake was, and still is, impounded by a terminal moraine at Jamestown. The lake in the Cassadaga Creek-lower Conewango Creek valleys was dammed by a terminal moraine in Pennsylvania about 6 miles south of Frewsburg. Morainic materials northeast of the village of Kennedy impounded another large lake in the upper part of the Conewango Creek valley. However, lakes are temporary features which are gradually filled with sediment and destroyed by the downcutting of their outlets. Flow from the lakes in the Cassadaga and Conewango Creek valleys gradually eroded away the morainal dams and the lakes disappeared except for a few remnant lakes in the Cassadaga Creek valley and large swamps in both valleys. The remainder of the present valleys have the flat bottoms which are characteristic of abandoned lake beds.

Evidence of former beaches along the sides of the Chautauqua Lake basin indicates that the lake was from 20 to 30 feet higher in relatively recent time. Exposed areas of the former lake bottom are found along the Chadakoin River, and near Bemus Point, Hartfield, and other localities along the lake shore. If the water level of the lake were lowered another 20 feet the entire southern half of the lake would be destroyed. However, a dam has been constructed at Jamestown to control the lake level. This dam has prevented the Chadakoin River from further downcutting through the large moraine at Jamestown and, thus, is prolonging the life of the lake.

The deposits left by glaciation cover all of the area with the exception of the southeast corner which was not glaciated. In some of the glaciated areas, particularly along streams subject to flooding, the glacial deposits are covered by a layer of sediment laid down during the last few thousand years. The extent of the various surficial deposits is shown in plates 1 and 2.

GLACIAL DEPOSITS

Several types of glacial deposits occur in the Jamestown area. These include deposits laid down directly by the ice (ice deposits); deposits formed by streams draining from the ice (melt-water deposits); and deposits laid down in lakes (lake deposits).

Ice deposits

The most widespread glacial deposit found in the area is till. This material, which was "plastered" over the land surface by the ice sheet, is generally found immediately above the bedrock although it may appear wherever the ice overrode previously existing material.

Till is generally found at the surface throughout the entire area shown as till and bedrock in plates 1 and 2. It is the only extensive unconsolidated deposit found in the uplands. Although till often is also present in the low-lying areas, it is overlain by other glacial deposits. The only low-lying areas where it regularly occurs at the surface are in the mixed deposits which are portions of moraines.

Till consists of a heterogeneous mixture of clay, silt, sand, gravel, and boulders. It is usually quite compact and is termed "hardpan" by most well drillers. The composition of till may vary greatly, even in the same locality, because the relative amounts of its different constituents depend on what materials the ice had picked up from the areas over which it had advanced. The till in the Jamestown area is predominantly clayey as most of its constituents were derived from the local shale bedrock. Lenses of sand and gravel are widely scattered through the till. In the large upland areas where till is exposed at the surface, some of the finer grained materials such as silt and clay have often been removed from the upper 2 or 3 feet by weathering and erosion. This causes the till to be quite sandy and much coarser at the surface than it is several feet below the surface. The water-bearing characteristics of the till are discussed under "Upland Areas" in the section on "Ground-Water Hydrology."

Melt-water deposits

As the ice became stagnant and melted, immense amounts of water, silt, clay, sand, and gravel were released from the ice. Large quantities of the coarse-grained material, the sand and gravel, were deposited in the valley areas close to the ice front as outwash sheets extending downstream from the front. Examples of these outwash deposits may be located in plates 1 and 2 near Cassadaga, in the area south of Bear Lake, and near Watts Flats. The deposits of sand and gravel near Cassadaga, Bear Lake, and Watts Flats are exposed at the land surface. Other deposits of sand and gravel, notably the deposit penetrated by the Jamestown supply wells, are not exposed at the surface. These deposits presumably were also laid down by streams carrying water down the valleys from melting ice. After the deposits were laid down, the valleys were occupied by lakes in which silt and clay was deposited on the sand and gravel. (See following discussion of "Lake Deposits.")

Sand and gravel was also deposited as terraces along the valley walls by streams running over and under the ice sheet. Such terraces occur northeast and south of Kennedy. Deposits of sand and gravel also occur in the morainal areas where they are completely interbedded with deposits of silt and clay and till. These areas are mapped as "mixed deposits" in plates 1 and 2.

The large fan-shaped deposits of sand and gravel on the valley floors, such as near Ross Mills and Kimball Stand (pl. 1), began forming at about the same time that the sands and gravels in the main part of the valley were being deposited by melt water from the receding ice sheet. During this period of ice-dammed glacial lakes, the tributary streams deposited the coarse-grained sediment derived from the uplands as deltas in the lakes. The deposition of sand and gravel as deltas continued in the lakes in the valleys even after the ice had completely left the area. Gradually the

lakes disappeared from all the valleys except that now occupied by Chautauqua Lake. The sand and gravel in the deltas built along the sides of the Cassadaga Creek valley interfinger with the buried outwash deposit that supplies the Jamestown wells. (This subject is discussed in greater detail in the section dealing with recharge and discharge of the Jamestown aquifer.)

Detailed descriptions of the occurrence of the sand and gravel deposits in the Jamestown area are given in the sections of this report dealing with the hydrology of the three major valleys.

Lake deposits

Deposits of clay and silt which were laid down in lakes are found in the valley bottoms. When lakes were impounded by the ice or the morainic deposits, the quiet water allowed the silt and clay derived from the melting ice to settle out. Thicknesses of these deposits in excess of 200 feet are found in parts of the larger valleys. The lake deposits usually contain alternating layers of silt and layers of clay ranging from a fraction of an inch to about 10 inches in thickness. These layers reflect the seasonal change in deposition in the lakes. During the summer periods as the ice melted, the coarser particles of silt were washed from the ice and deposited while water currents prevented deposition of the clays. During the winters the clay suspended in the water was able to settle out because the currents subsided as melting stopped for the winter. The most extensive of these lake deposits is shown as areas of silt and clay in plates 1 and 2. Lake deposits of silt and clay also occur at a few places along the valley walls as much as 100 feet above the valley floors. These deposits appear to have been laid down in small lakes which were impounded for short periods between the ice tongues and the walls.

As mentioned in the preceding section on melt-water deposits, there are deposits of sand and gravel interbedded in the lake deposits. The origin of these sand and gravel deposits poses problems beyond the scope of this report. For instance, there are three separate layers of sand and gravel interbedded with more than 400 feet of silt and clay in the lower portion of the Cassadaga Creek valley. The most extensive of these layers occurs at a depth of 120 feet at the Jamestown well field, is about 20 feet thick, and covers several square miles in area. This deposit is believed to have been formed during a period when the valley was not occupied by a lake.

The distribution of the lake deposits is discussed in greater detail in the discussion of the hydrology of the valleys.

NONGLACIAL DEPOSITS

Deposits of silt and clay are still being formed in the lakes that are present today. For example, silt deposition is becoming a problem in some areas of Chautauqua Lake. Mucklands found in parts of the valleys are also examples of recent deposition. Muck is formed by the partial decay of organic material and is still forming in most of the swamps.

The unconsolidated surficial materials in the southeastern corner of the area have probably been forming since long before the first glaciation of the region because there is no evidence of glaciation in that area. This surficial material consists of a soil which has been developed by thousands of years of weathering of the bedrock surface.

Occasionally, during floods, the streams in the area overflow their banks. Flooding of the tributary streams entering the valleys from the uplands results in the deposition of a small amount of coarse-grained material on the delta deposits on the valley floors.

THE WATER CYCLE

HYDROLOGIC CYCLE

All the water found in the project area, with the exception of a small amount flowing across the northern boundary of the area in Conewango Creek, is derived from local precipitation. As precipitation falls, some of it immediately runs over the land surface and into the streams, lakes, or ponds; a part of it evaporates from the land and water surfaces and is, thus, returned to the atmosphere; some infiltrates into the soil where it is used by plants and transpired back to the atmosphere; and the remainder percolates down through the soil and reaches the zone in which all openings are filled with water (the zone of saturation). The surface of this zone is called the water table. The zone of saturation extends far below the water table to a point where pressure becomes so great that no openings exist to contain water. The zone between the land surface and the water table is known as the zone of aeration because it contains both water and air. A certain amount of water is held in this zone by molecular attraction while excess amounts percolate downward to the water table. The depth to the water table is different from place to place in the area and fluctuates seasonally through a range of several feet. The zone of aeration is nonexistent in some areas, such as swamps, where the water table is at land surface. The water table is generally 5 to 10 feet below land surface in the uplands and as much as 70 feet below land surface on some of the sand and gravel terraces along the valley walls. Once water reaches the water table, it moves laterally under the influence of gravity to points of discharge such as springs and streams, and is then carried out of the area. An idealized illustration of this cycle of events is shown in figure 7.

The process by which water is returned to the atmosphere, through evaporation and also transpiration by plants, is called evapotranspiration. The amount of water which falls on an area during any year is approximately equal to the amount which is lost by evapotranspiration and stream discharge. This balance, between the amount of water received and the amount discharged, is called the water budget.

All water in the Jamestown area is derived from precipitation. There are many factors which determine the amounts of precipitation that will be used in meeting requirements for various parts of the water budget from year to year, especially the amount which will enter the ground and percolate to the water table. These include (1) the amount, intensity, and seasonal distribution of precipitation; (2) air temperature; (3) type and amount of vegetation; (4) the porosity and permeability of the surface deposits and bedrock; and (5) the slope of the land surface.

FIGURE 7 IN POCKET WITH PLATES

PRECIPITATION AND EVAPOTRANSPIRATION

The climate of the region is of the humid-continental type, characterized by long cold winters and short warm summers. The U.S. Weather Bureau station in Jamestown is the only long-term weather station in the project area. Records have been collected there continuously, with the exception of a few months, since 1896. Mean monthly temperature, total precipitation, and snowfall at Jamestown are shown in figure 8.

The average annual precipitation at Jamestown is 42.65 inches and the mean annual air temperature is 49.1°F (Fahrenheit), (U.S. Weather Bureau, 1960). Precipitation is distributed quite evenly throughout the year with the exception of slightly lower amounts in February and August. Snowfall comprises a large percentage of the annual precipitation. Mean annual snowfall is 92.6 inches at Jamestown. Snowfall often occurs irregularly over the region. The northern part of the area lies within the Lake Erie snow belt and storms moving out of the Lake Erie basin often drop much larger

amounts of snow on and near the escarpment than they do farther south. The average length of the growing season at Jamestown is 144 days. This is somewhat longer than the season in the adjacent uplands.

Precipitation may fall as snow or rain and an entire monthly total may fall during only a few days of the month. If large amounts of rainfall occur over short periods of time, much of the water is lost through overland runoff to the streams because the soil cannot absorb the water as fast as it falls. However, all or nearly all of a drizzle will soak into the ground. If precipitation occurs as snow, it is stored on the surface of the ground and has an opportunity to be absorbed by the soil slowly, if melting is not too rapid.

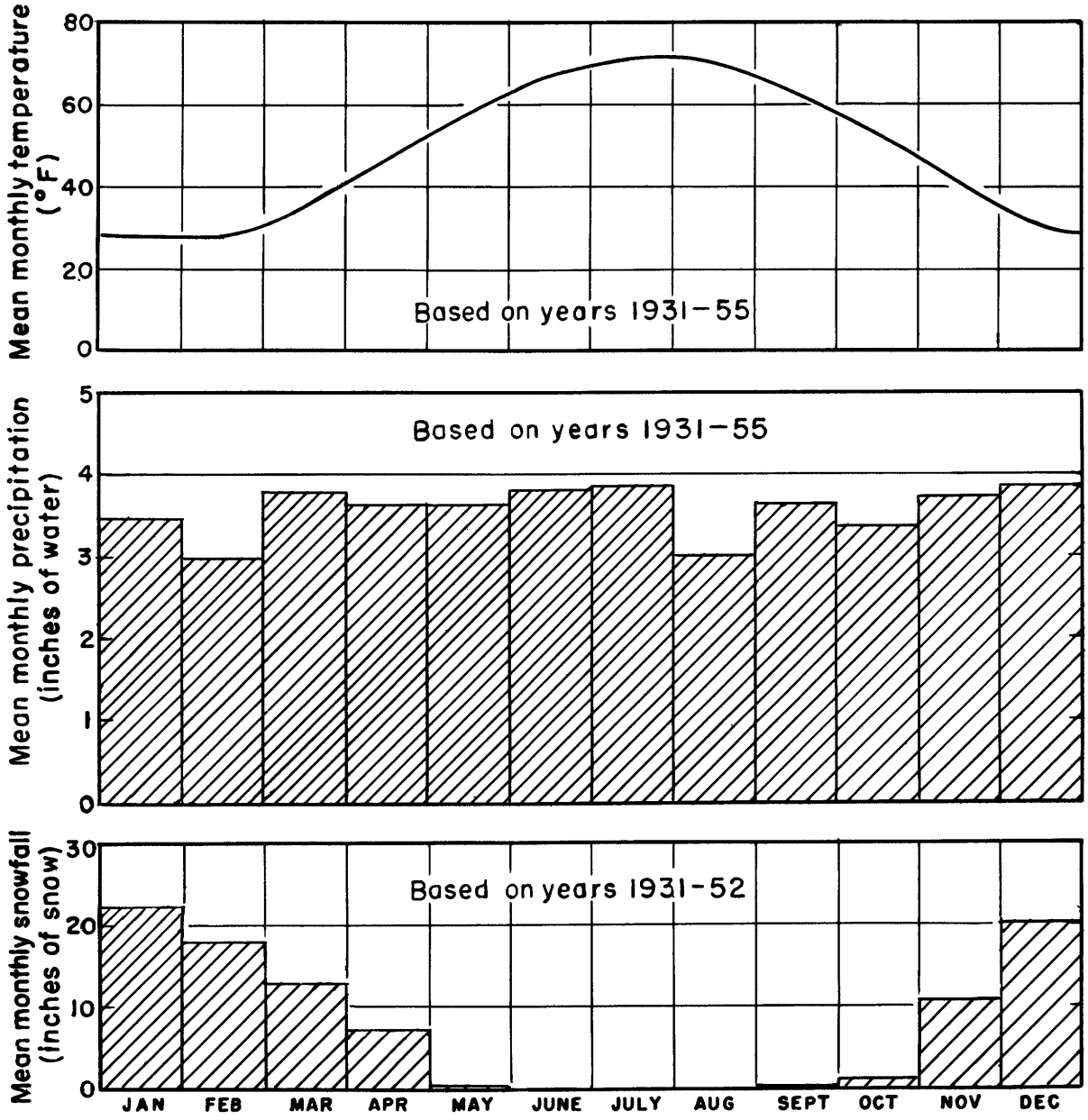


Figure 8.--Mean monthly temperature, total precipitation, and snowfall at Jamestown. The mean monthly precipitation includes the water content of snow.

Due to higher air temperatures, a large part of the precipitation during the summer is lost by evaporation before it can enter the ground. Conversely, during the fall, winter, and spring, evaporation may return little of the precipitation to the atmosphere, thereby allowing more water to infiltrate. Because the growth of vegetation reaches its peak during the summer, most of the water absorbed by the ground during this period is intercepted by the soil zone and is used by plants. Large amounts of water are required for plant growth, and during periods when rainfall is scarce, water stored in the soil zone is depleted. Thus, the precipitation that infiltrates into the ground during the summer is used to replenish this soil moisture and little, if any, percolates through the zone of aeration to the water table. The first killing frost in the fall stops the use of water by plants.

INFILTRATION AND OVERLAND RUNOFF

The porosity and permeability of the surface and subsurface deposits are the properties which determine the rate and amount of infiltration into the ground. The porosity of a material is the percentage of its total volume that is comprised of voids or openings. This directly affects the amount of water that may be stored in the material. For example, a rock with a porosity of 40 percent has openings making up 40 percent of its total volume. Permeability is the ability of a material to transmit water. The more permeable a material, the more rapidly it can transmit water. This property is dependent upon the size, shape, number, and interconnection of the openings in a rock in contrast to porosity which depends only on the number and size of openings. As is well known, a given quantity of water can move more readily through a large-diameter pipe than through a small-diameter pipe. For the same reason, a larger quantity of water can move more easily through a rock which has large, well connected pores, than can move through a rock with small, poorly connected pores. The permeability of both bedrock and of unconsolidated deposits is expressed as the number of gallons of water that will move in one day through a 1 square-foot area under a hydraulic gradient of 100 percent (1-foot drop in head for each foot of horizontal movement). The permeability of a sand and gravel may be as much as 5,000 gpd (gallons per day) per foot. The permeability of a clay or a shale bedrock may be less than 1 gpd per foot.

Figure 9 demonstrates the relationships between the porosity and permeability of some common types of rocks found in the Jamestown area. The blocks of material on the left side of the figure are labeled with common values for the porosity of the different rock types that occur in the area. The different porosities show a wide range. The porosity of the bedrock is very low since the only openings are the thin bedding joints and near-vertical joints. The remainder of the block is solid rock.

The till has a relatively low porosity since it is composed of a mixture of different size grains. The large boulders, cobbles, and smaller stones have smaller grains between them. These smaller grains all have still smaller grains in the spaces between them. This makes the till very compact with nearly all of the openings being very minute. The silt and clay block has a surprisingly large porosity. The grains are very small and the openings between them are, in turn, very small but they are so numerous that their

FIGURE 9 IN POCKET WITH PLATES

total volume is large. The sand and the gravel blocks have fairly high porosities but not as high as the silt and clay. If the sand and gravel contains only minor amounts of smaller size grains, the openings between the grains will also be quite large and freely connected.

The row of blocks down the middle of the figure illustrates specific yield and specific retention. For example, the saturated block of bedrock has a porosity of 2 percent. As the block is allowed to drain it will yield only a part of the water it contains. The water released from the rock is called the specific yield and is expressed as a percent of the total volume of the rock it represents. The water held by the rock which is retained as a film along the sides of the fractures through molecular attraction is called the specific retention. This is also expressed as a percentage of the total rock volume. In the case of the bedrock example, the specific yield and specific retention were each 1 percent which total the porosity of 2 percent. This indicates that the bedrock will yield only about half the water it contains.

The examples of the other deposits in figure 9 demonstrate the differences in specific yield and specific retention. The figure shows that the till, and the silt and clay, yield very little of their water. The sand and the gravel are at the other extreme as they yield most of their water and retain very little.

It should be emphasized that the values for porosity, specific yield, and specific retention in figure 9 are only relative. Since there is an infinite number of variations in grain size, compaction, and sorting of the grains, the properties discussed and shown also have a large range of values.

On the right side of figure 9 are diagrams illustrating the relative permeabilities of these different rocks. The water taps are all discharging water at the same rate. The buckets, containing samples of the rocks, are open at the bottom so that water may pass through freely. The water has great difficulty passing through the bedrock, silt and clay, and till. These substances would be regarded as relatively impermeable. However, because the water passes through the sand and the gravel very easily, they are relatively permeable.

Thus, it can be seen that precipitation falling on one of the more impermeable materials, such as till, cannot infiltrate readily and will tend to run off over the land surface. Just the opposite is true for a surface underlain by sand and gravel where the much higher permeability allows rapid infiltration. Other factors also influence the amount and rate of infiltration and overland runoff. The slope of the land surface, soil development, and vegetation also influence the infiltration rate regardless of the permeability of the surface material.

The amount of water reaching the zone of saturation is highly variable with respect to time. At certain times the amount exceeds the rate at which water is discharging from the zone and the amount of ground water in storage increases. At other times no infiltration reaches the zone of saturation and the amount of ground water in storage declines.

Some of the complex interrelationships between precipitation, evapotranspiration, overland runoff, and infiltration can be illustrated with figure 10. This figure shows the monthly lowest water level in well 203-929-1 for the period 1953-62, the monthly precipitation at Jamestown, and the computed amount of water surplus at Jamestown during the same period. The well is located about 10 miles west of Jamestown in a till aquifer, and in approximately the same climatic environment as Jamestown. The water surplus represents the amount of water available for infiltration or overland runoff after demands for evapotranspiration are met. The water surpluses were computed according to a method devised by Thornthwaite (1957). This method provides reliable estimates of the amount of water lost by evapotranspiration. It considers such factors as rainfall, air temperature, duration of sunlight, and moisture-holding capacity of the soil. The amount of water lost by evapotranspiration is subtracted from the total monthly precipitation. The amount left is the water surplus. A soil moisture content of 4 inches of water was used in these computations. Although this figure for soil moisture may not be correct over all parts of the area, it is a reasonable average. The exact amounts of the surplus, in inches of water over the area, are also only approximately correct. However, the method allows a reasonable estimate of monthly water surplus and reveals the months when there is a surplus or deficit of water. It should be noted that the water surplus includes both ground-water recharge and overland runoff.

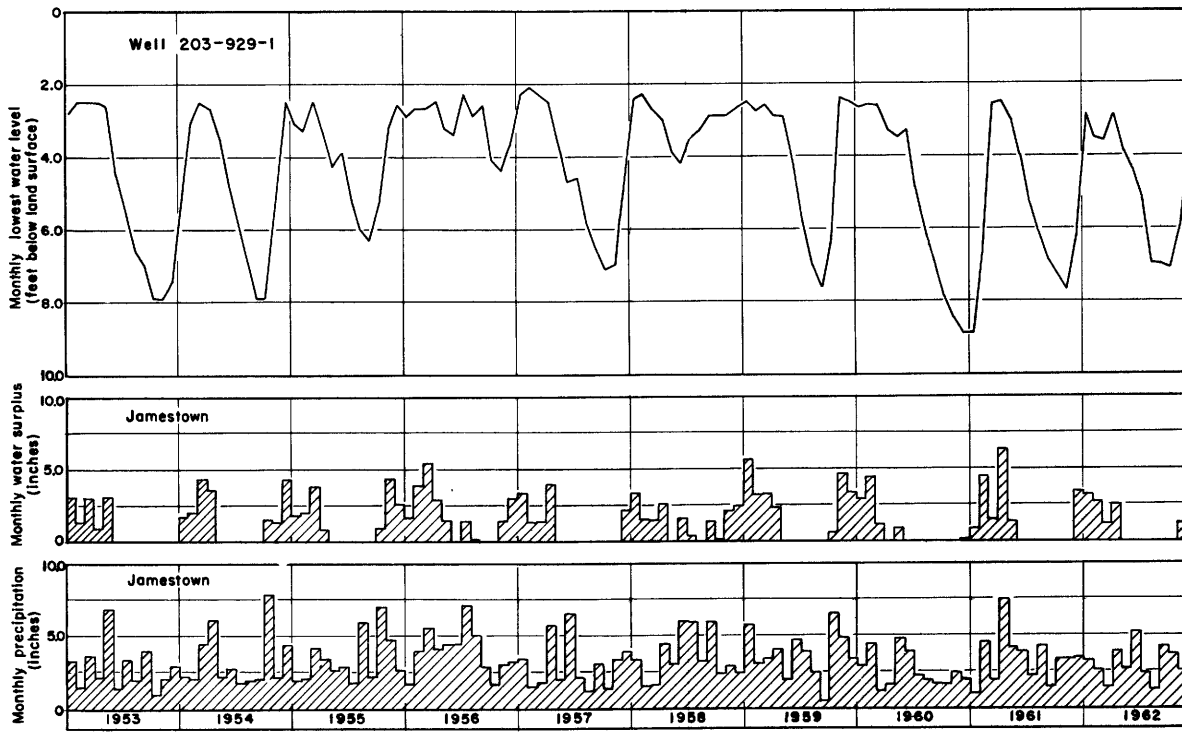


Figure 10.--Monthly lowest water level in well 203-929-1, monthly water surplus, and monthly precipitation at Jamestown, 1953-62.

During the months when a water surplus was available, as shown in figure 10, the water level in well 203-929-1 rose or remained level. In months when no surplus was available, and hence, no ground-water recharge occurred, the level in the well declined, as water discharged naturally from storage in the aquifer. During the winter and some of the fall and spring months, when air temperatures are low and vegetation is dormant, much surplus water is available, as evidenced by the rise in water level. During the summer, as temperatures rise and plant growth becomes rapid, all of the precipitation is used for evapotranspiration and no surplus water is available for ground-water recharge. There are some exceptions to this, notably the years of 1956 and 1958, when rainfall during the summer exceeded the evapotranspiration demands and water was available for recharge. Some small declines may also be noted during the winter months when frozen ground prevents infiltration. In these cases most of the water surplus still remains on the ground as snow and is available for release early in the spring. The time lags that may be noted on the graphs between water surpluses or deficits, and rises or declines in the water level, are due to the time required for water to percolate through the zone of aeration and reach the water table.

GROUND-WATER HYDROLOGY

As water percolates down to the water table, it is added to storage in the zone of saturation. The rocks and unconsolidated deposits in the zone of saturation serve as reservoirs for the storage of water and as pipelines to transmit water. Those deposits which will yield usable quantities of water are termed aquifers. However, the term aquifer is relative. Till may be considered an aquifer in some areas where more permeable deposits do not exist. In areas containing sand and gravel deposits, till would not be considered as an aquifer or a source of water.

As soon as the water reaches the water table, it begins to move laterally down the slope of the water table to some point of discharge. The rate of this movement is determined by the slope of the water table and the permeability of the material through which the water is moving. The rate of ground-water movement may vary from a few feet per year in clay or till, to several feet per day in a coarse sand and gravel. The water moves down the slope of the water table until it reaches a point of discharge, such as a spring or stream, where the water table intersects the land surface. Quite often in the valleys of the Jamestown area, the aquifer through which the water is moving becomes confined under an impermeable material such as clay. The pressure created by the weight of the water in the upslope portion of the aquifer causes a pressure to be exerted upward on the confining material. This results in artesian conditions and when the aquifer is tapped by a well, the water level will rise above the top of the aquifer. If the pressure is high enough, the water may even flow above land surface.

Figure 11 shows an idealized diagram illustrating the occurrence of ground water under water-table and artesian conditions. As the water moves downslope under water-table conditions, it becomes confined under artesian pressure where it moves under the confining bed as shown in the figure. The water throughout the artesian aquifer remains under a head supplied by the weight of water at the point where the water is first confined.

When the artesian aquifer is tapped by a well, the water will rise to a height in the well equal to the head supplied by the upslope (recharge) area of the aquifer, minus some loss of head due to friction as the water moves through the aquifer. The level to which water will rise in wells tapping the artesian aquifer is termed the piezometric surface. In an artesian system the aquifer remains completely full of water and the pressure in the system changes in response to recharge and discharge.

A discussion of ground-water hydrology includes a description of the occurrence, movement, recharge, discharge, and availability of ground water. In order to facilitate the discussion of the hydrology of the Jamestown area, it has been divided into four areas which will be discussed separately. These areas are (1) the uplands, (2) the Cassadaga Creek valley, (3) the Chautauqua Lake valley, and (4) the Conewango Creek valley.

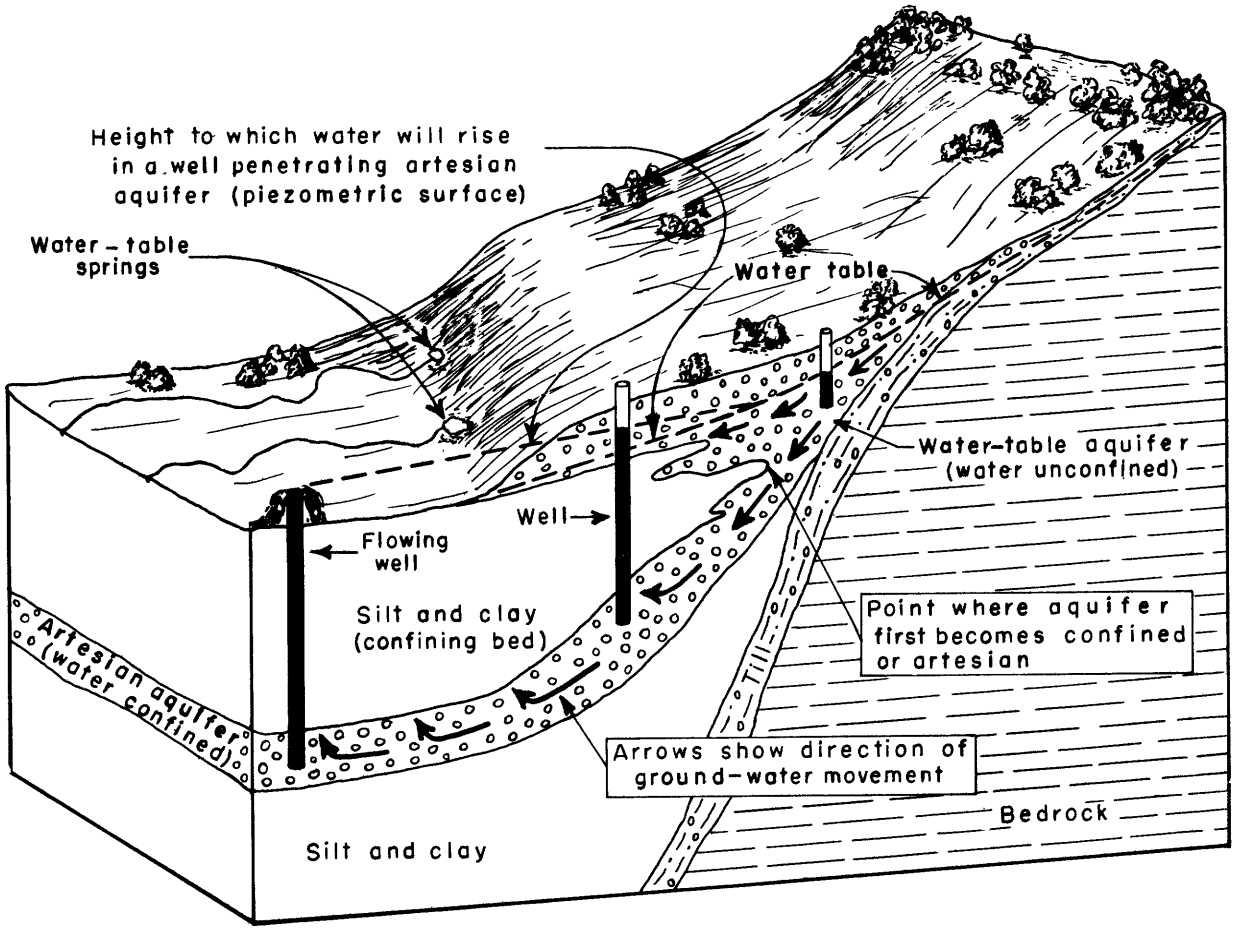

Height to which water will rise in a well penetrating artesian aquifer (piezometric surface)
Water-table springs
Water table
Water-table aquifer (water unconfined)
Well
Flowing well
Silt and clay (confining bed)
Artesian aquifer (water confined)
Point where aquifer first becomes confined or artesian
Till
Arrows show direction of ground-water movement
Bedrock
Silt and clay

Figure 11.--Idealized diagram showing the occurrence of water under water-table and artesian conditions.

The wells, test borings, and springs discussed on the following pages may be located in plates 1 and 2, and data concerning them is presented in tables 6 and 7. Graphic logs for selected wells and test borings are shown in figure 43.

UPLAND AREAS

The portion of the area of investigation which will be considered as the uplands in this report includes all the areas shown in plates 1 and 2 as being underlain by till. All upland areas can be treated conveniently as a unit because of the relative uniformity of the deposits and the similarity of ground-water occurrence. This is true also for the nonglaciated area where the deposits consist of a residual soil developed from the underlying shale bedrock. The water-bearing characteristics of the soil in this area are similar to the till that is present in the remainder of the uplands.

WATER-BEARING DEPOSITS

As previously mentioned, the only extensive deposits which are found in the uplands are till and bedrock. The till averages about 25 feet in thickness and covers the bedrock nearly everywhere. In some small areas, particularly along some steep slopes, bedrock is exposed at the surface; in other areas the till may reach a thickness of more than 100 feet. An idealized section of the occurrence of these deposits is shown in figure 12. The soil overlying the bedrock in the nonglaciated area in the southeastern corner of the area ranges in thickness from a few feet on steep hillsides to about 20 feet on the flatter areas.

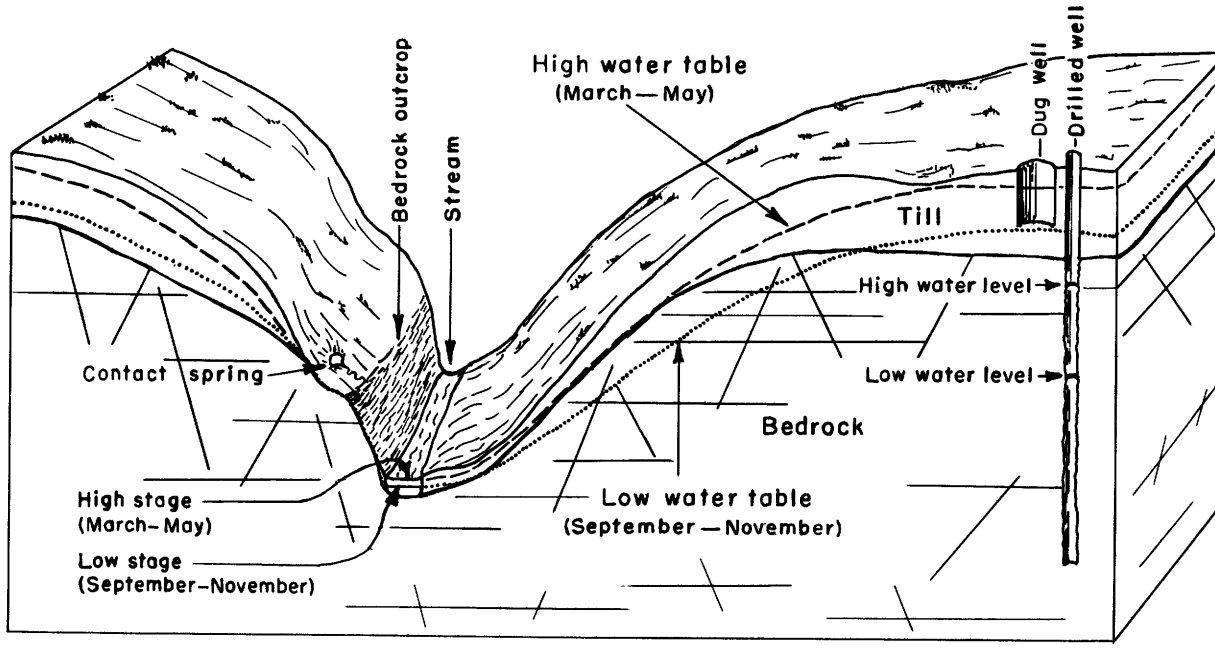


Figure 12.--Idealized section showing the occurrence of deposits in the uplands and the relative yearly fluctuations of the water table.

The composition of the till does not vary greatly throughout the area and the water-bearing character, therefore, is generally the same throughout the area. The till is relatively impermeable because of its unsorted character and because of the high percentage of silt and clay which it contains. However, locally the till may contain lenses of sand and gravel up to an inch or more in thickness. These lenses are much more permeable than the till as a whole, and they locally increase its permeability.

The composition and character of the bedrock is also very much the same throughout the entire area. The bedrock contains water in fractures and joints resulting in a low permeability. This permeability gradually decreases with depth because the openings along the joints become smaller as pressure, caused by the weight of overlying rock, increases.

In many areas of the uplands, the contact between the till and the bedrock is indistinct and consists of a zone where the lower few feet of the till is composed predominantly of fragments of the underlying bedrock, and the upper surface of the bedrock is highly fractured. This zone was formed by the crushing action of the glacial ice which broke thin-bedded rocks, such as those underlying the Jamestown area, into small irregular-shaped fragments. This zone of broken bedrock has a higher permeability than either the overlying till or underlying bedrock. For convenience in this report it will be referred to as a "rubble zone."

Recharge and discharge

All the ground water in the uplands is derived from local precipitation. The till has such a low permeability that much of this precipitation is unable to infiltrate into the soil, and it runs off over the land surface into streams. The fairly steep hillslopes, of course, facilitate the overland runoff.

Most ground-water recharge occurs during the fall, winter, and spring when evapotranspiration losses are low. Snow is probably the most effective source of ground-water recharge in the uplands because it tends to melt slowly and thus, has a greater opportunity to soak into the ground. Most precipitation during the summer occurs as thunderstorms. Precipitation accompanying these storms is very intense and greatly exceeds the infiltration rate. As a result, most of it runs off over the land surface.

After the water which soaks into the ground percolates down to the water table, it begins to move laterally downslope through the till and bedrock to points of discharge such as streams or springs and seeps along the hillsides. During the summer the evapotranspiration rate equals in some areas the rate at which water moves through the till and bedrock. When this happens, the flow of streams in the uplands becomes very low and may even cease entirely.

In general, streams in the uplands tend to be "flashy." In other words, during a heavy rain they carry large amounts of overland runoff and their flow increases rapidly, while after the rain their flows decrease rapidly.

The seasonal fluctuation of the water table is much greater in the higher altitudes because of the movement of ground water from the hills into the adjoining valleys. Figure 12 shows the relative fluctuation of the water table in the hill and in the valley areas. The ground water moving toward the valleys tends to replenish the water that has moved from storage in these areas into the streams. As there is generally no significant recharge during the summer, the ground water moving toward the valleys is derived from upland ground-water storage. It may be observed in figure 12 that the water level in the drilled well is further below land surface than that in the dug well. This reflects the loss of head as the water moves downward from the till through the bedrock.

Yields

The yield of most wells in the uplands is only a few gallons per minute. The yield of wells in the same type of water-bearing materials vary widely over short distances and depend on the type of well, topographic position, character of the aquifer, and the spacing of wells.

Ground water in the uplands is obtained by means of dug wells, drilled wells, and springs. Dug wells are particularly effective in the withdrawal of water from till. The large diameter of dug wells provides a large reservoir in which ground water accumulates while the well is not being pumped. Even though the till is a very poor aquifer, this storage feature provides enough water for short periods of large demand.

The yields of till wells are variable but generally average less than half a gallon per minute. Successful dug wells usually intersect one or more sand lenses in the till. These small lenses, as previously mentioned, are fairly abundant in the till and greatly increase its water-transmitting capacity. The topographic position of a dug well also affects its yield. Because a dug well cannot be excavated for any great distance below the water table, those that are located on hilltops or the higher slopes tend to go dry during dry summers. This is caused by the larger fluctuation of the water table in these areas as shown in figure 12. In many places these wells can be deepened while the water table is low.

Water is recovered from the bedrock aquifer by drilled wells. The success of a drilled well in the bedrock seems to depend to a great degree on the character and thickness of the overlying till, the topographic position of the well, and the number of water-bearing fractures penetrated.

The existence of a moderately permeable zone, the rubble zone referred to earlier, along the contact of the till and the bedrock surface is an important factor in the yield of bedrock wells in the upland areas. This zone, where it exists, will usually contribute more water to wells than either the till or the bedrock. In fact, the rubble zone appears to contribute most of the water in many bedrock wells. In several drilled wells in the uplands, water was observed running into the wells around the bottom of the casing. The yield of none of these wells exceeded 6 gpm and it appeared that as much as 75 percent of the total yield was being contributed by this zone.

The amount of water in storage in the bedrock is very small and most of the water pumped from bedrock wells probably percolates down fractures from the overlying till. Therefore, bedrock wells generally have a larger and more dependable sustained yield where the rock is overlain by at least 15 to 20 feet of till. The topographic position also has an effect on the yield of drilled wells. Because ground water moves from the uplands to the valleys, more water is available to replenish storage at lower altitudes.

Several water supplies in the uplands are derived from springs which are outcrops of the water table at the land surface (fig. 12). The yield of individual springs in the uplands ranges from less than 1 to about 10 gpm. Most springs in the uplands discharge water from the rubble zone immediately above the bedrock. In many places, instead of a distinct springhead, there

is a wet seepage zone 20 to 30 feet wide. Because springs are outcrops of the water table at the land surface, any fluctuation of the water table is very critical with respect to their yield. A slight decline in the water table is enough to decrease the yield of a spring substantially. Therefore, springs tend to be undependable sources of water during dry periods.

Most springs that are used as water supplies are developed by constructing a small structure, similar to a shallow dug well, in and around the spring seep. This structure acts as a storage reservoir and the water is usually delivered by gravity pipeline.

PRESENT SUPPLIES

Domestic and farm

Most of the water used in the uplands is for domestic and farm supplies. There are thousands of these supplies with individual use ranging from about 50 to 1,000 gpd. By far, the largest proportion of these supplies are obtained from dug wells and springs although drilled wells in bedrock are becoming more common because of the more permanent nature of the supply.

Public supplies

There is some use of ground water from the uplands for public water supplies (fig. 3). The village of Sinclairville utilizes a spring supply (217-913-1Sp) northwest of the village. The flow of several springs has been combined at this site. Total yield of the springs is about 22 gpm and the estimated daily use is 30,000 gallons. The spring supply is supplemented by a well in the valley-fill deposits at the south boundary of the village.

The village of Cherry Creek also has a spring supply (217-908-1Sp). A total of seven springs has been developed at this site. The springs have a total yield of about 60 gpm and the estimated average daily use is 90,000 gallons. The system also includes a well in the valley-fill deposits at the west edge of the village which is used to supplement the spring supply during periods of heavy use or drought.

Spring 209-906-2Sp is used to supply 14 families at Kennedy. This spring is also supplemented by a well.

The village of Brocton, which lies to the north of the area of investigation, utilizes a surface-water supply. The village has a reservoir on Slippery Rock Creek northwest of Bear Lake in the area of investigation (fig. 3). However, since the flow of the creek becomes very low during dry periods, an auxiliary pipeline to Bear Lake is also available for use. Average daily use by the village is 385,000 gallons.

Industrial supplies

The only industrial supplies in the uplands are located in the vicinity of the Jamestown Municipal Airport (pl. 1). Two industries utilize drilled

wells in bedrock. The average combined use by these companies is reported to be about 90,000 gpd.

FUTURE SUPPLIES

Only small supplies of ground water can be developed in the uplands. The yield of most upland wells is generally less than 5 gpm. Yields of as much as 20 to 30 gpm are seldom obtained. Even if the yield of a bedrock well is only a gallon or two per minute, the depth of the well will often provide enough storage for an adequate domestic supply.

The future development of large supplies of ground water in the uplands, such as would be required by some industries or public supplies, is limited. Due to the low permeability of the till and bedrock, wells having large yields are not to be expected. Although some public supplies have been developed, they all must be supplemented with water from the valley-fill deposits. Some wells are being used for industrial purposes but the industries involved do not have large water needs.

CASSADAGA CREEK VALLEY

The Cassadaga Creek valley includes the lowland area drained by Cassadaga Creek from the headwaters in the vicinity of Bear Lake and the Cassadaga Lakes to Hartson Swamp. It includes the portion of the Cassadaga Creek valley northeast of Falconer across which the Chadakoin River flows before it enters Cassadaga Creek. The character of the deposits underlying the surface of the valley is shown in plate 1. The water-bearing character of the deposits is shown in plate 3.

The valley of Cassadaga Creek is filled with a great thickness of unconsolidated material. Plate 3 shows this thickness through the use of contours of the altitude of the bedrock surface based upon both observed and reported depths to bedrock. The location of wells tapping bedrock may be found in plate 1. Depths to bedrock of 571 feet and 565 feet are reported for wells 210-915-1 and [illegible]-912-33, respectively. The depth to bedrock is not known in the valley [illegible]th of well 210-915-1. However, well 217-918-3 reached a depth of 305 feet without entering bedrock and well 222-919-1 was terminated at 314 feet without reaching rock. These data suggest a great thickness of valley fill all the way to the very northern head of the valley. Depths to bedrock in the portion of the valley occupied by Bear Lake range from about 100 to 160 feet.

South of the Jamestown well field, the thickness of unconsolidated material is not quite as great. A depth to bedrock of 329 feet is reported at well 207-910-8 and 196 feet at well 207-910-5.

Most of the unconsolidated deposits in the Cassadaga Creek valley consist of silt and clay (pl. 1). Silt and clay underlies the land surface throughout most of the central part of the valley from the vicinity of Stockton and Cassadaga downstream to Hartson Swamp. Mixed (morainal) deposits of gravel, sand, silt, clay, and till occur at the northern ends of the valley, north of Bear Lake and the Cassadaga Lakes, and along the

valley sides north of Hartson Swamp. Extensive deposits of sand and of gravel occur at the surface, both at the northern ends of the valley and as fan-shaped deposits along the valley sides to the vicinity of Hartson Swamp.

As noted above, the Cassadaga Creek valley is underlain by nearly 600 feet of unconsolidated deposits in the lower end of the valley (near Gerry and at the Jamestown well field). Most of this material consists of silt and clay. An exception to this is in the fan-shaped sand and the gravel deposits built along the valley sides which generally extend downward to bedrock and which interfinger with the silt and clay deposits. Sand and gravel deposits as much as 20 feet thick are also known to be interbedded with the silt and clay in parts of the valley.

The character of the unconsolidated deposits in the Cassadaga Creek valley along certain vertical profiles is shown in figures 13, 14, and 15. Each of these profiles was drawn across sections of the valley where the character of the material was known from test wells or from reports of well drillers. The logs of the wells used in drawing the sections plus the logs of other wells are shown in figure 43. The sections in figure 13 are across the upper ends of the valley in the vicinity of Bear Lake and Lower Cassadaga Lake. Most of the upper layers in this part of the valley are composed of sand or gravel. The coarse-grained layers are underlain by clay and silt or till.

Figure 14 is a section across the valley at Gerry. This section crosses the delta of Hatch Creek on the north side of the valley and the delta of an unnamed creek on the south side. It shows, therefore, coarse-grained deposits of sand and gravel on both the north and south sides of the valley. Because detailed logs of the material penetrated by the wells are not available, it is not possible to show the complex interfingering of the sand and gravel layers with the silt and clay. The sand and gravel deposit penetrated between altitudes of 1,095 and 1,115 feet in wells 210-915-1 and -2 is a part of the Jamestown aquifer which will be discussed in the following section. It may be observed that another layer of sand and gravel was penetrated also at an altitude of about 1,000 feet, approximately 100 feet below the Jamestown aquifer. The log for well 211-915-1 suggests that the well penetrated numerous layers of sand interbedded with silt and clay. However, the driller did not keep a detailed record of the different layers.

Section A-A' in figure 15 crosses the Cassadaga Creek valley near the junction of Cassadaga Creek and the Chadakoin River. The section shows a complex interlayering of sand and gravel and silt and clay. The sand and gravel deposit penetrated at an altitude of about 1,140 feet in wells 207-910-8 and 208-910-2 is a part of the Jamestown aquifer. The sand and the complexly interbedded sand, gravel, silt and clay at the left (south) side of the section appears to be a part of the moraine that was built by the ice across the lower end of the Chautauqua Lake valley.

All the sand and gravel deposits in the Cassadaga Creek valley are sources of ground-water supply. For convenience, these deposits will be divided into the following groups for purposes of discussion: (1) Jamestown aquifer, (2) deltas as aquifers, and (3) deposits in the upper Cassadaga Creek valley.

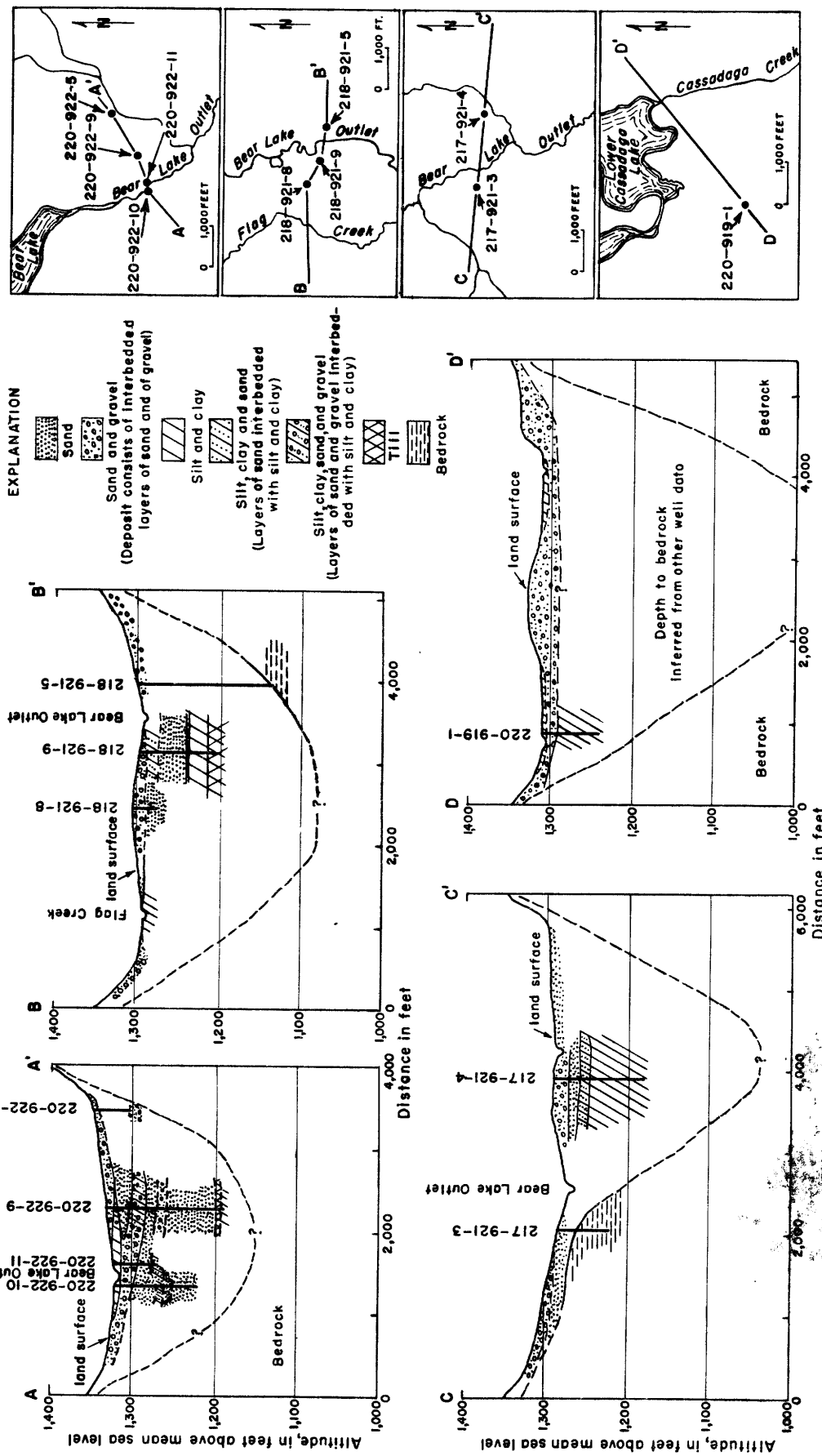


Figure 13.--Geologic sections across the upper part of Cassadaga Creek valley.

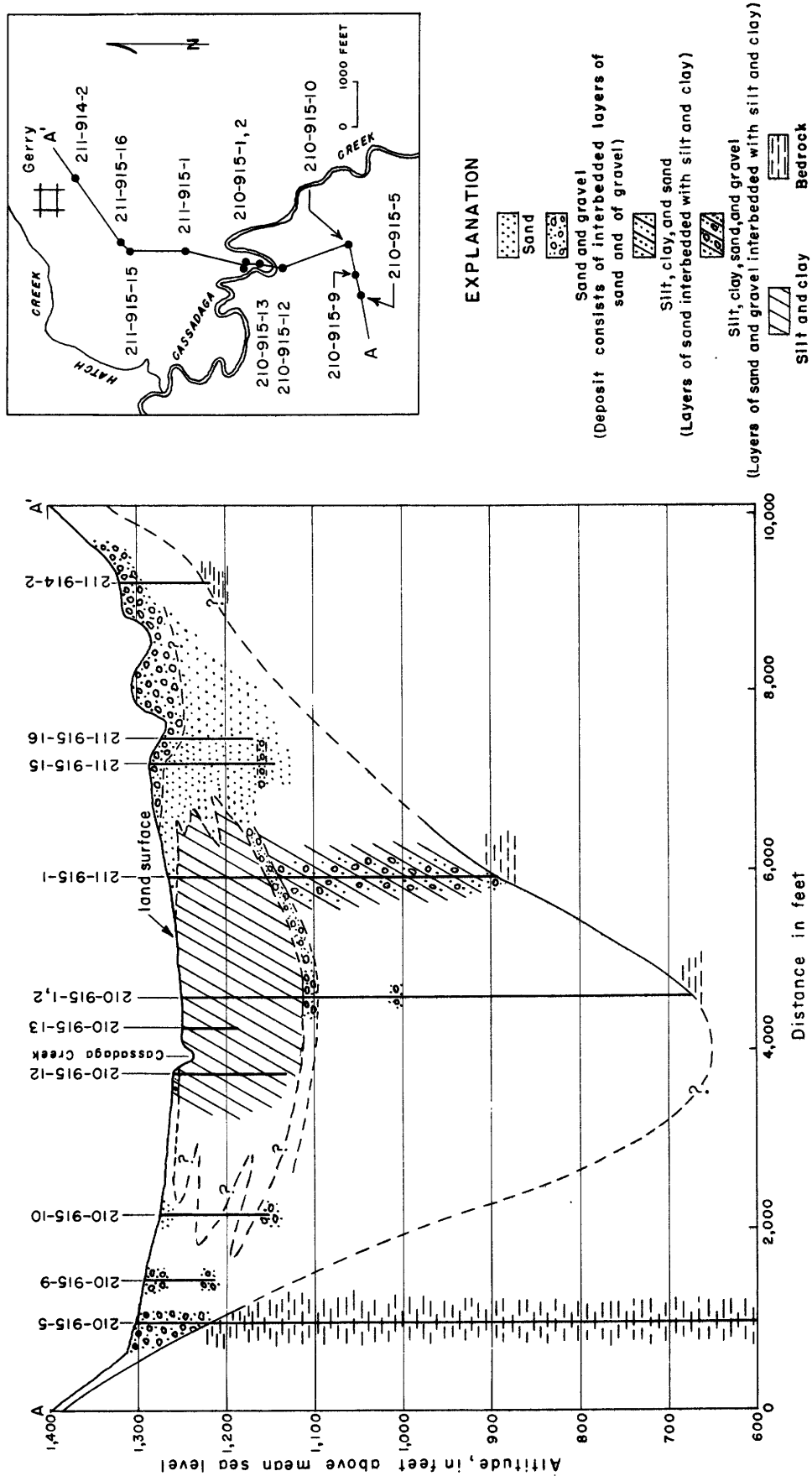


Figure 14.--Geologic section across Cassadaga Creek valley at Gerry.

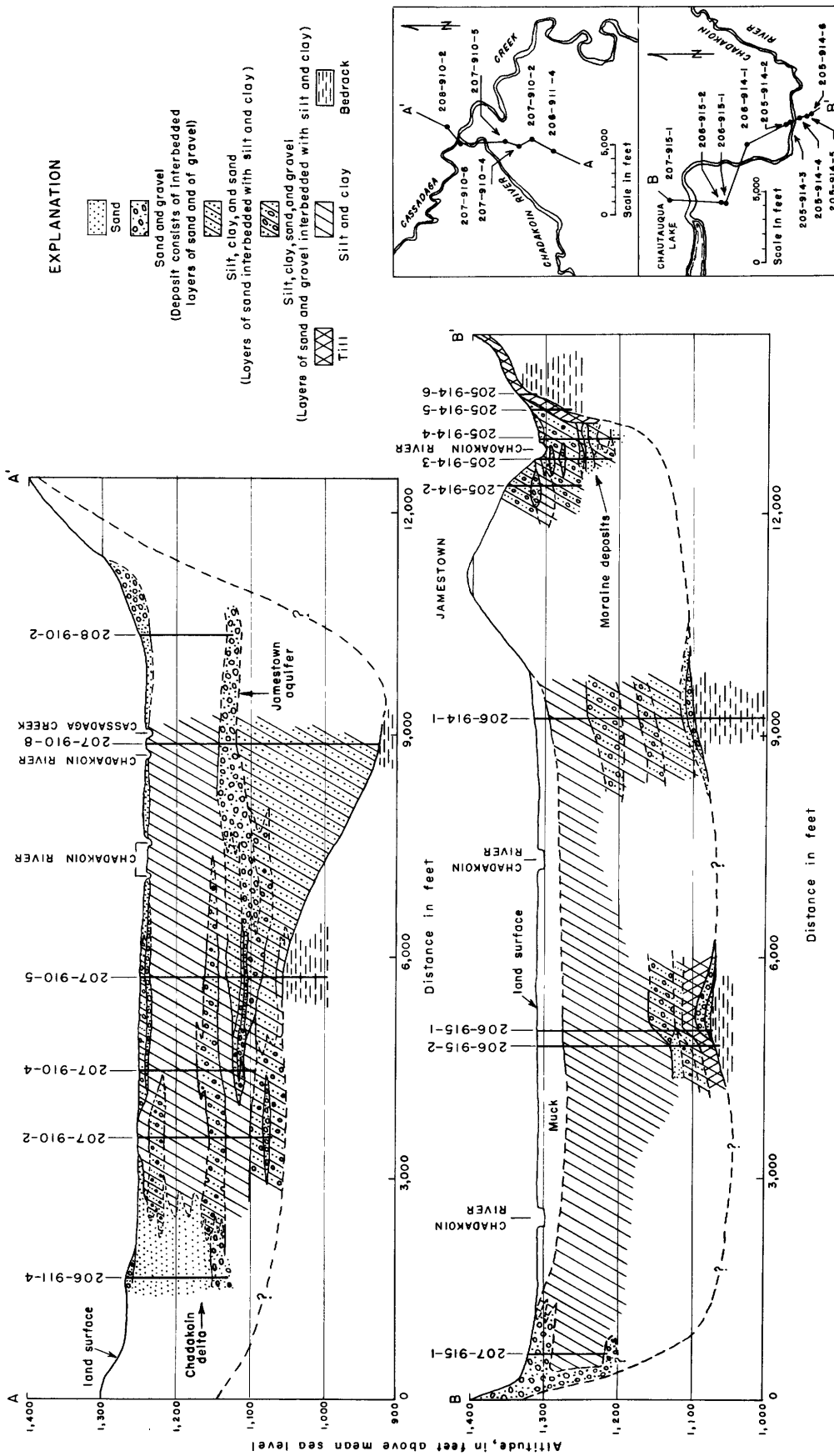


Figure 15.--Geologic sections along the Chadakoin River and across the junction of the Chadakoin River and Cassadaga Creek.

JAMESTOWN AQUIFER

The sand and gravel deposit tapped by the Jamestown public supply wells is the most important source of ground water in the area. For convenience in the following discussion this aquifer is herein referred to as the Jamestown aquifer.

The extent of the Jamestown aquifer is shown in figure 16. As may be seen from the figure, it extends from Hartson Swamp up the Cassadaga Creek valley to the vicinity of Towerville Corners. The aquifer consists of sand and gravel. Composition of the aquifer seems to be relatively consistent throughout its area except in the Towerville Corners area where it is predominantly a gravelly fine sand. Near Towerville Corners the aquifer reaches a thickness of about 40 feet. At the Jamestown well field it ranges from about 15 to 20 feet thick and consists of coarse sand and gravel. At well 207-908-3 in Hartson Swamp, the aquifer consists of 20 feet of medium to coarse sand and gravel. It thins to less than 10 feet to the south and east of the swamp.

The aquifer is overlain and underlain by deposits of silt and clay which confine the water in it under artesian pressure. The thickness of the confining layer overlying the aquifer ranges from about 80 feet in the Hartson Swamp area to about 140 feet in the vicinity of Towerville Corners. The thickness of the confining bed is about 120 feet at the Jamestown well field. The data from wells suggest that the aquifer extends to the south of Hartson Swamp past well 206-908-6. If the aquifer does, in fact, extend into this area the confining bed is absent in a small area south of the 1,210-foot contour in figure 16. The depth to the top of the Jamestown aquifer, and therefore, the thickness of the confining bed is shown at several points in figure 16.

The aquifer reaches its highest altitude south of Hartson Swamp. The altitude of the top of the aquifer declines to the north up the Cassadaga Creek valley to an altitude of less than 1,120 feet in the Ross Mills-Towerville Corners area.

Jamestown well field

The city of Jamestown has been obtaining its water supply from the Jamestown aquifer since at least 1888. The first well field and pumping station were located on the east bank of Cassadaga Creek at Levant (fig. 16) about 2 miles northeast of the city. The Levant site contained 15 wells on 4 acres of land which flowed above land surface when not in use. They were pumped by a siphon arrangement which delivered water to the pumping station and was then pumped into the distribution system. This water supply system, owned by private interests, was purchased by the city of Jamestown in 1903. Soon thereafter, the city became concerned about the adequacy of the supply at this site and began an investigation to locate an additional source of supply.

It was determined during the investigation that the Cassadaga Creek valley was still the best area for the development of a water supply. About 1915, work was begun on a new well field in the Jamestown aquifer at a site

approximately 1 mile northwest of the Levant pumping station. Ten wells were drilled at the new location. These wells were finished with casing from land surface to the top of the aquifer, 20 feet of perforated casing through the aquifer, and 100 feet of casing below the aquifer. The casing below the aquifer was installed to permit the wells to be pumped by the "air-lift" method. The city planned to use the new field in conjunction with the Levant wells.

However, due to the fact that the Levant station was in need of extensive repairs and the location was subject to inundation during floods, it was decided to abandon the Levant pumping station entirely and to locate a new pumping station at the site of the new wells on the west bank of the creek.

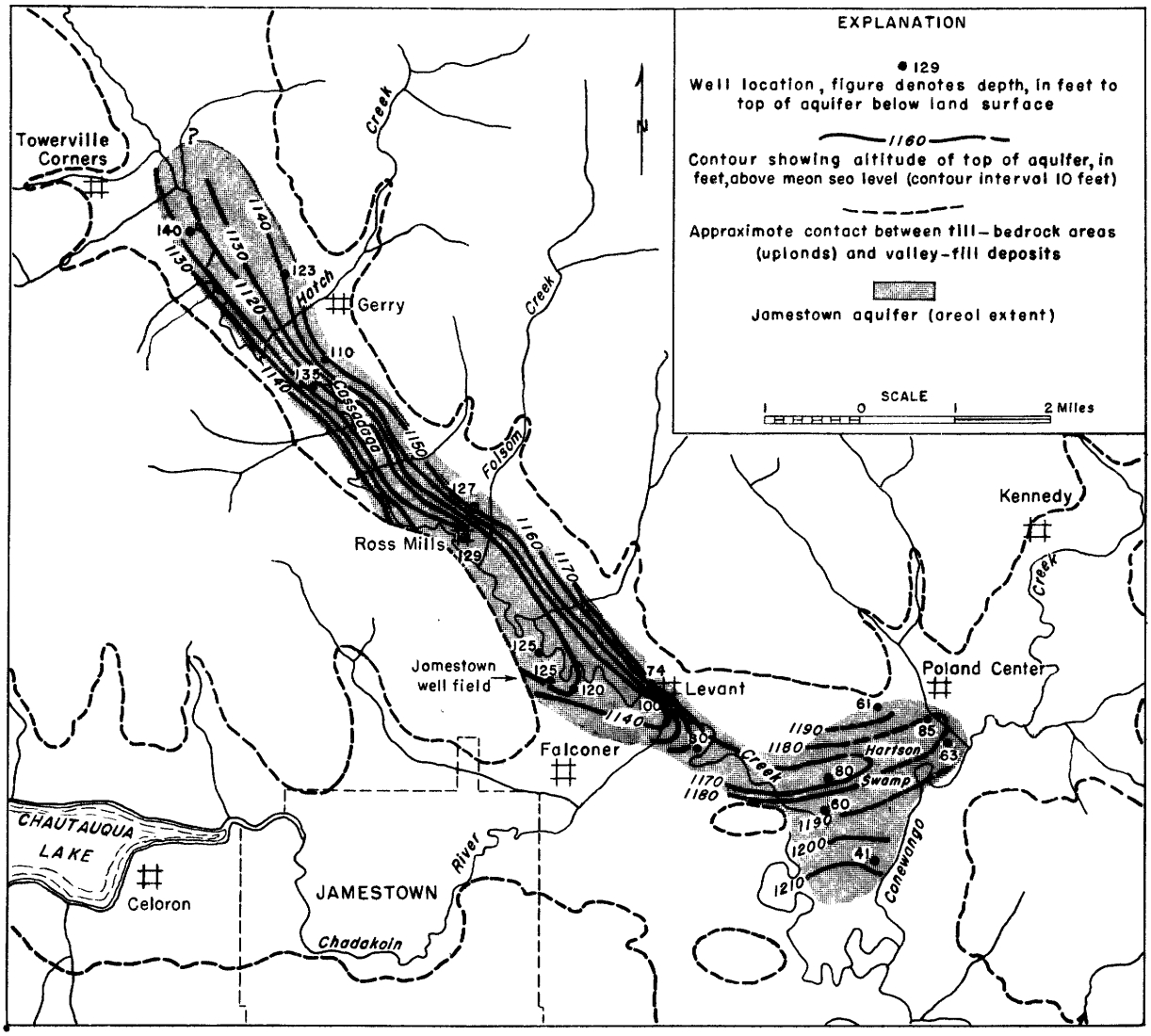


Figure 16.--Areal extent and altitude of the top of the Jamestown aquifer.

Before the new well field was placed in service, it was decided not to use the 10 wells drilled for the "air-lift" method and instead to drill 9 new wells to be pumped by siphon in order to avoid pumping costs. The 10 wells drilled for the "air-lift" method were held in reserve to be used only if drawdowns became too great to siphon the water. A receiving well 30 feet in diameter and 50 feet deep was constructed as a part of the siphon system. This receiving well permitted the siphons on the supply wells to lower water levels in the well field to approximately 35 feet below land surface. The water was pumped from the receiving well into the distribution system. The new well field was put into operation in 1923 at which time the Levant station was permanently abandoned.

By the 1940's daily pumpage at the Jamestown well field occasionally exceeded 5 mgd and water levels, especially during the summer, became critical as far as the siphon system was concerned. Since pumping the unused "air-lift" wells at the field by the "air-lift" method was considered obsolete and inefficient, it was decided to drill new wells and equip them with deep-well turbine pumps. In 1947, seven new wells were drilled and equipped with pumps. In 1956, an additional well was drilled and in 1957, two of the wells originally intended for the "air-lift" method were equipped with deep-well pumps.

Figure 17 shows the location of all the wells and test borings around the Jamestown well field. The location of the wells presently equipped with deep-well pumps is indicated.

Pumping rates at the Jamestown well field have shown a progressive rise since the late thirties (fig. 4) and are now (1965) approaching an annual rate of 6 mgd. Water levels at the well field have declined steadily with the increasing pumping rate and during recent summers have declined to more than 60 feet below land surface. The decline in water levels has for several years been of concern to the city. This concern has naturally centered around the maximum perennial yield of the Jamestown aquifer. Because of the importance of the aquifer as a source of water supply, a determination of the perennial yield is essential to the city's long-range plans. A study of the yield formed an important part of this investigation. The determination of the yield requires an understanding of the hydrology of the aquifer, especially where the water is coming from, how it moves through the aquifer, and where it is being discharged.

Hydrologic situation

Prior to the withdrawal of water from the Jamestown aquifer by the city, the water in the aquifer was under sufficient pressure to rise above land surface. No static water-level measurements made at the time have been preserved, but the water level is reported to have risen as much as 10 feet above land surface at the present well field (Merle W. Smedberg, oral communication). (It is possible that this value reflects some drawdown from the Levant well field.) Prior to the start of large-scale withdrawals, it is probable that water levels were above land surface throughout the aquifer. The pumpage at the Jamestown well field has depressed water levels throughout the aquifer and wells no longer flow at land surface south of Ross Mills. Water levels between Ross Mills and Gerry rise above land

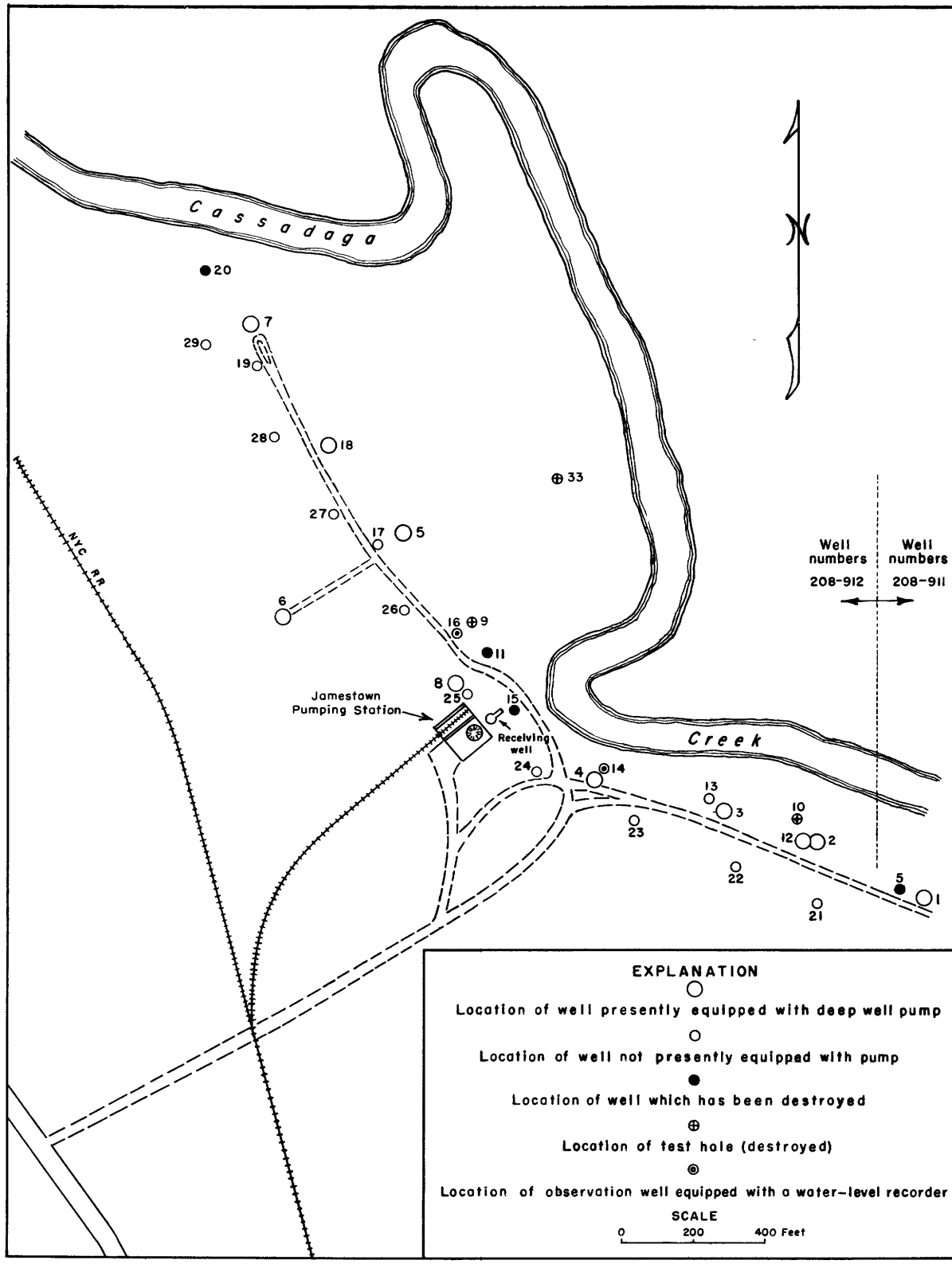


Figure 17.--Location of pumped wells, abandoned wells, and test holes in the Jamestown well field.

surface only during the spring of the year. North of Gerry water levels are still above land surface year round and at well 212-916-1 are as much as 20 feet above land surface in the spring. Thus, the pumpage has essentially stopped all natural discharge except in the northern part of the aquifer.

On the basis of the artesian pressures discussed above, it is obvious that a hydraulic gradient existed between the Jamestown aquifer and the land surface prior to the start of large withdrawals. As a result of this gradient, water discharged upward from the aquifer into Cassadaga Creek and the adjacent surficial deposits. This discharge was undoubtedly at a slow rate because of the substantial thickness and low permeability of the silt and clay confining bed. The decline of artesian pressure accompanying the pumpage has stopped this discharge in the vicinity of the well field and has substantially decreased it in all other areas.

The conditions governing natural discharge from the aquifer are readily apparent from the water-level data cited above. The conditions governing recharge, on the other hand, are much more obscure. Howard Cranston, consulting engineer of Fredonia, N. Y., theorized in a report prepared for the city in 1946 that the aquifer is recharged through the extensive surficial sand and gravel deposits in the vicinity of Bear Lake and Cassadaga Lakes. (See plate 1.) (It was not possible to locate a copy of the Cranston report during this investigation. However, a detailed summary of it appears in an article by John K. Loope which was published in the Jamestown Post-Journal of January 7, 1947.) Cranston postulated that the deposits near Bear Lake and the Cassadaga Lakes were a continuation of the Jamestown aquifer and that they disappeared under the silt and clay deposits in the valley to the south. Because there is a difference in elevation of 50 feet between the valley floors in the upper prongs of the Cassadaga Creek valley and the valley floor at the well field, Cranston believed that water entered the sand and gravel deposits in the upper portion of the valley and moved down the valley under the confining bed to the Jamestown well field. Cranston based his conclusions largely on surficial geologic data.

In addition to the theory advanced by Cranston, it was thought at the start of this investigation that at least two other sources of recharge might exist. One of these was by leakage from Cassadaga Creek vertically downward through the confining beds in the vicinity of the well field and the other was by seepage into the aquifer along the margins of the valley. As noted above, it was known that natural discharge from the aquifer, prior to the start of large withdrawals, was by upward leakage through the confining bed. However, no information was available on the amount of the leakage. The confining bed was known to be composed of 120 feet of silt and clay at the present well field which precludes very substantial movement of ground water, but it was possible that the confining bed was thinner or composed of more permeable sediments along other parts of the stream. If so, it was visualized that substantial recharge might occur through such areas under pumping conditions.

With respect to lateral seepage into the aquifer along the margins of the valley, it was known at the start of the investigation that the deltas built by the tributary streams, such as Folsom Creek along the margins of the valley, were composed of sand and gravel. However, it was not known

whether these deposits extended downward to the level of the Jamestown aquifer. It was recognized that if they did, substantial recharge might enter the aquifer through the deltas.

All of the three possible sources of recharge discussed above were based mainly upon surficial geologic evidence, and it was apparent at the beginning of the investigation that an intensive study of the Cassadaga Creek valley would be needed to determine which was the principal source. The investigation in the valley consisted of three principal phases. The first was devoted to a study of existing wells and to the construction of test holes and test wells to determine the extent and character of the aquifer and the thickness and character of the confining bed. The second phase was devoted to the collection of data on the flow of Cassadaga Creek and its tributaries to determine where water was being lost from the streams. The third phase consisted of the collection of data on water levels to determine the direction of movement of water in the aquifer and the areal extent of the cone of depression developed around the well field.

Recharge in upper Cassadaga Creek valley.--The depth, yield, character of the deposits penetrated, and other data were compiled for all known deep wells and many shallow wells in the Cassadaga Creek valley. Because most of the people reside along the sides of the valley, relatively few wells were found in the central part of the valley where data were needed most. It was necessary, therefore, to drill test holes and test wells to supplement the data from existing wells.

The extent of the aquifer, as determined from the well data, is shown in figure 16. No deposits recognizable as a part of the Jamestown aquifer were found north of well 212-916-1, located about a mile southeast of Towerville Corners. According to Cranston's theory the depth to the top of the aquifer should decrease up the Cassadaga valley. However, figure 16 shows that the depth to the top of the aquifer actually increases up the valley. A test hole (214-918-9) near South Stockton, drilled with a power auger, penetrated about 10 feet of interbedded clay, silt, and sand at the surface and 122 feet of silt and clay. If the aquifer exists at this location it is more than 132 feet below land surface and is obviously not hydraulically connected to the sand and gravel that underlies the surface in the upper prongs of the Cassadaga Creek valley. It is remotely possible that the thin sand bed penetrated at a depth of 250 feet by well 217-918-3, near the junction of the two prongs of the valley, is a part of the Jamestown aquifer. This sand bed, if it is a part of the aquifer, is separated from the surficial sand layer by 210 feet of silt and clay. Data from wells suggest that the Jamestown aquifer does not extend into the upper parts of the Cassadaga Creek valley. If the aquifer does extend into the valley, it is overlain by more than 200 feet of silt and clay which would prevent any substantial recharge from the surficial deposits.

Data from existing wells and test holes on the deltas along the valley sides show that the deposits of sand and gravel comprising the deltas extend downward to the thin till deposit overlying bedrock. Well 209-913-12, northeast of Ross Mills (pl. 1), also showed that the sand and gravel layers of the delta of Folsom Creek interfinger with the silt and clay layers that

overlie the Jamestown aquifer. The interfingering of the deposits is shown in figure 18. This figure also shows a hydraulic connection between the delta and the aquifer although such connection was not indicated by the well data. Further discussion of the hydraulic connection between the delta and the aquifer appears in a following section.

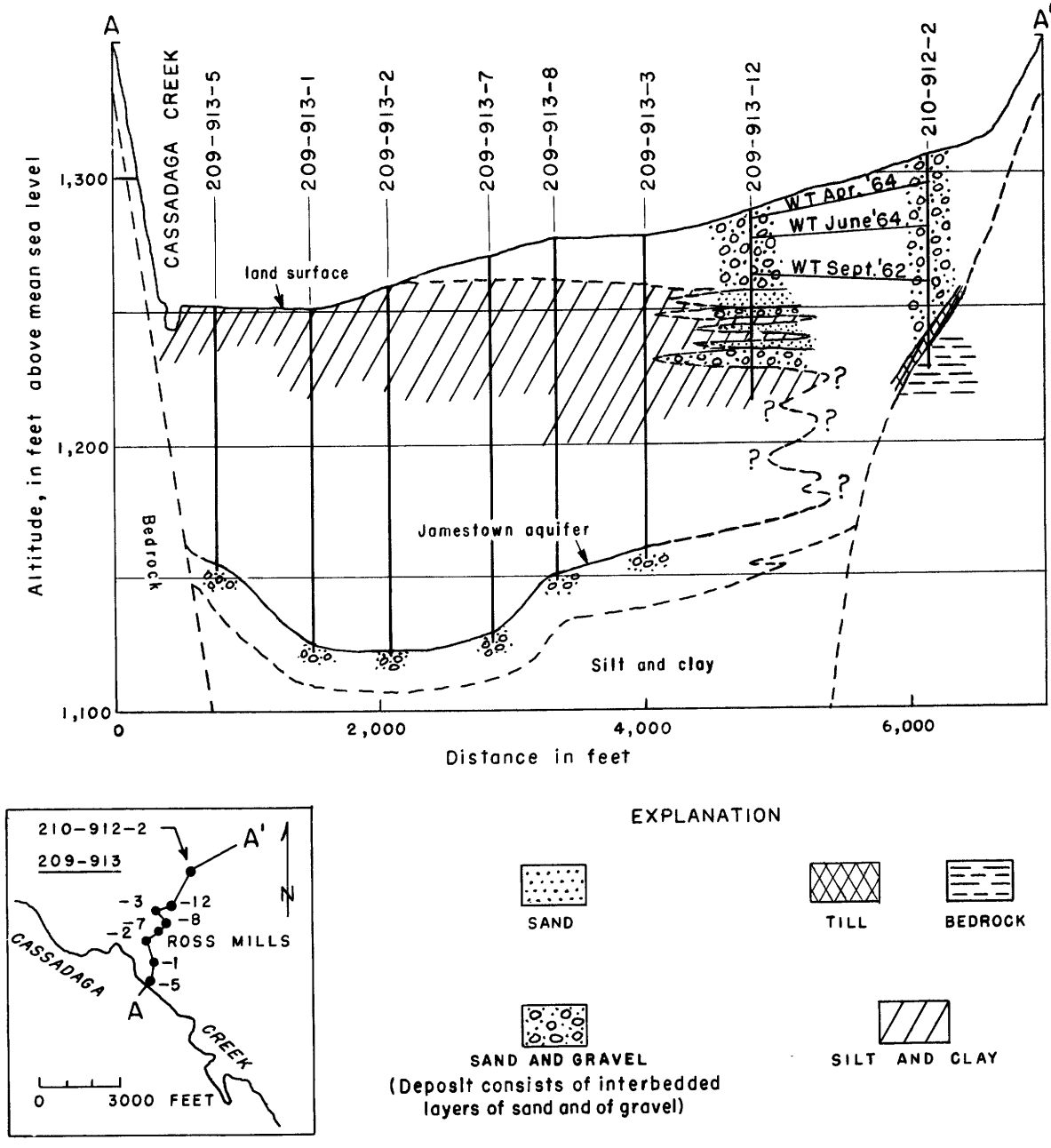


Figure 18.--Geologic section across the Cassadaga Creek valley at Ross Mills.

Recharge from Cassadaga Creek.--The well data collected during the first phase of the study showed that the confining bed above the Jamestown aquifer became thinner to the southeast. However, the data did not indicate any change in permeability of the bed. Thus, the possibility of substantial recharge occurring by downward seepage from Cassadaga Creek did not appear promising at the conclusion of the first phase of the study. However, the discharge of Cassadaga Creek and its tributaries in the vicinity of the well field was measured at several sites during periods of low flow to determine if the flow decreased in the vicinity of the well field. A decrease in flow would indicate downward seepage of water into the aquifer. Measurement sites are shown in figure 20 and the measurements are tabulated in table 2.

It may be observed from the measurements made on June 26-27, 1962, that the flow of Cassadaga Creek was 32.6 cfs (cubic feet per second) at site 15 and only 32.7 cfs at site 10 about 2 miles downstream. Normally, the flow of a stream increases in a downstream direction. The increase in flow of only 0.1 cfs does not indicate a loss of water but rather the lack of inflow from the tributaries in this stretch of channel as indicated by the measurements at sites 12 and 14. A substantial loss of water from Cassadaga Creek should be apparent in a comparison of the measurements for sites 10 and 1 because the well field is located approximately midway between these sites. Instead of a loss, such a comparison shows a pickup of 1.3 cfs. Therefore, it may be concluded that seepage from Cassadaga Creek into the aquifer is negligible.

Recharge through deltas.--The first and second phases of the study indicated that no substantial amount of recharge to the Jamestown aquifer was occurring either at the upper ends of the Cassadaga Creek valley or by downward seepage from Cassadaga Creek in the vicinity of the well field. The only obvious source left was by lateral seepage into the aquifer from the delta deposits along the margins of the valley. In this regard, it will be recalled that data from existing wells and test holes had shown that sand and gravel under the deltas extended downward to bedrock or to the thin layer of till that overlies the bedrock in parts of the valley. However, the well and test-hole data were insufficient to show hydraulic continuity between the deltas and the aquifer.

There were two different approaches that could be taken to prove, or disprove, hydraulic continuity. One is direct; the other indirect. For example, direct proof, or disproof, could be shown with a line of closely spaced test holes extending from one of the deltas into the center of the valley. If such holes showed a continuous permeable layer extending from the delta to the aquifer, continuity would be established. Continuity could also be positively established if water-level fluctuations caused by pumpage at the Jamestown well field were observed in an observation well in the deltas.

Two test holes were drilled into the delta of Folsom Creek (fig. 18). Test hole 209-913-12 was drilled into the zone where the delta deposits interfinger with the silt and clay, but because of a shortage of funds had to be terminated above the level of the Jamestown aquifer. Lack of funds precluded the construction of the additional wells needed to prove continuity.

Following the completion of test wells 210-912-2 and 209-913-12, water-level recording gages were installed on the wells to observe changes in ground-water storage in the deltas and to determine if water-level fluctuations caused by pumping at the Jamestown well field were observable in the delta. With respect to water-level fluctuations, the Jamestown well field is generally pumped at a constant rate except for a shutoff period of 8 to 10 hours on Saturday night or Sunday morning of each week. This shutoff is accompanied by a rapid recovery of water levels in the vicinity of the well field. The recovery of water levels during a shutoff period of 9 hours and 45 minutes on October 14, 1962, is shown in figure 19. During this shutoff the water level in well 208-912-16, near the center of the well field, rose 20.6 feet. The rise at well 209-913-1, 1.5 miles to the north was 3.2 feet and the rise at well 207-908-3 in Hartson Swamp, 2.7 miles to the southeast was 0.63 foot. The two test wells in the delta are located 2.0 and 2.2 miles from the well field. At this distance a rise in water level of about 2 feet might be expected. However, such a rise was not observed in the wells in the delta. This is not surprising because water in the deltas is under water-table conditions and even a small fluctuation represents a substantial volume of water. In other words, a clearly discernible water-level fluctuation in the delta would probably require a much larger fluctuation than the 2 feet produced by the October 14 shutoff. A larger fluctuation could be produced by a longer shutoff period. However, the city's reservoir storage capacity is not adequate to permit a longer shutoff. Therefore, water-level observations had to be abandoned so far as direct observation of hydraulic continuity was concerned, and it was necessary to approach the problem through indirect means.

The indirect approach to the problem involved three different kinds of data: (1) streamflow data, (2) ground-water temperature data, and (3) water-level data.

Streamflow measurements made during the summer of 1962 and the spring of 1964 are compiled in table 2. The sites of these measurements are shown in figure 20. All these measurements were made during fair-weather periods when the streams were being supplied entirely by ground-water discharge. The measurements in 1962 show a loss of water where the tributary streams, such as Folsom Creek, cross their deltas. This loss of water could be interpreted in either of two ways. It could represent a movement of water through the deltas into the Jamestown aquifer or a movement of water into the delta deposits, either to satisfy natural evapotranspiration losses from the deltas or the loss of water by seepage at the land surface around the margins of the deltas. The water budget of the deltas, including the seepage losses from the streams, was analysed to determine how much water was being lost from the deltas. This analysis utilized the 1964 streamflow measurements.

The measurements in April 1964 were made under base-flow conditions at a time when the streams were flowing across the entire deltas. The two subsequent sets of measurements were also made under base-flow conditions, but later in the spring when streamflow had decreased substantially and some reaches of the streams were dry. The delta of Folsom Creek near Ross Mills was chosen for analysis because of the availability of ground-water level information and data on the extent and character of the delta deposits.

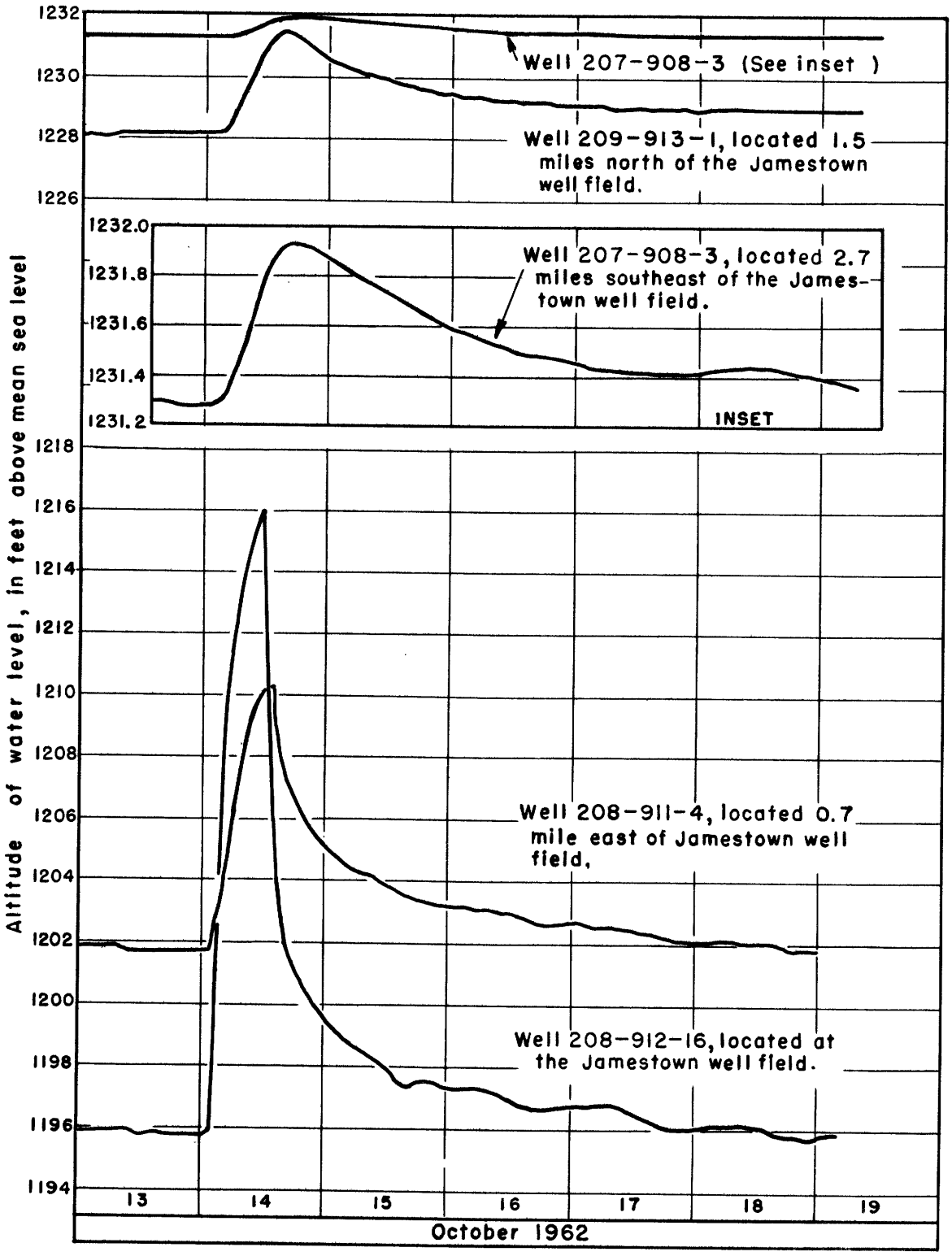


Figure 19.--Rise of water level in four wells penetrating the Jamestown aquifer caused by shutdown of the Jamestown well field for a period of 9 hours and 45 minutes.

Table 2.--Streamflow measurements made in the Cassadaga Creek valley

Site number	Drainage area (square miles)	Discharge in cfs (cubic feet per second)			
		June 26-27 1962	April 27 1964	May 18 1964	June 18 1964
1	141	34	----	----	----
2	.84	0	----	----	----
3	3.50	0	1.73	0	0
4	3.40	.14	2.37	1.28	0
5	2.74	.23	2.01	1.06	0
6	6.42	.34	3.70	.89	.10
7	.15	0	.1	0	0
8	5.53	0	4.66	1.42	0
9	4.11	.53	4.05	2.20	.44
10	126	32.7	----	----	----
11	----	----	1.23	.56	0
12	1.13	0	.51	.26	.08
13	2.34	----	1.58	.91	0
14	2.29	.13	1.33	1.05	.09
15	118	32.6	----	----	----
16	6.53	1.27	2.44	1.97	.49
17	6.11	0	4.63	1.45	0
18	4.97	1.23	4.28	1.59	.30
19	.93	.3	----	----	----
20	.48	.5	----	----	----
21	.07	Trace	----	----	----
22	.54	do.	----	----	----
23	3.74	0	----	----	----
24	3.43	.1	----	----	----
25	4.32	.34	----	----	----
26	3.78	.78	----	----	----
27	24.8	4.94	----	----	----
28	.06	.96	----	----	----

This analysis involves the measurement or estimation of the amounts of water entering the delta and the amounts leaving the delta. For the delta of Folsom Creek, the water budget may be stated as follows:

$$P + I = \Delta S + D_s + D_a + ET$$

where:

P = precipitation on the surface of the delta,
I = total streamflow onto the delta,
ΔS = change in ground-water storage in the delta,
D_s = stream discharge from the delta,
D_a = subsurface discharge from the delta,
ET = evapotranspiration from the delta surface.

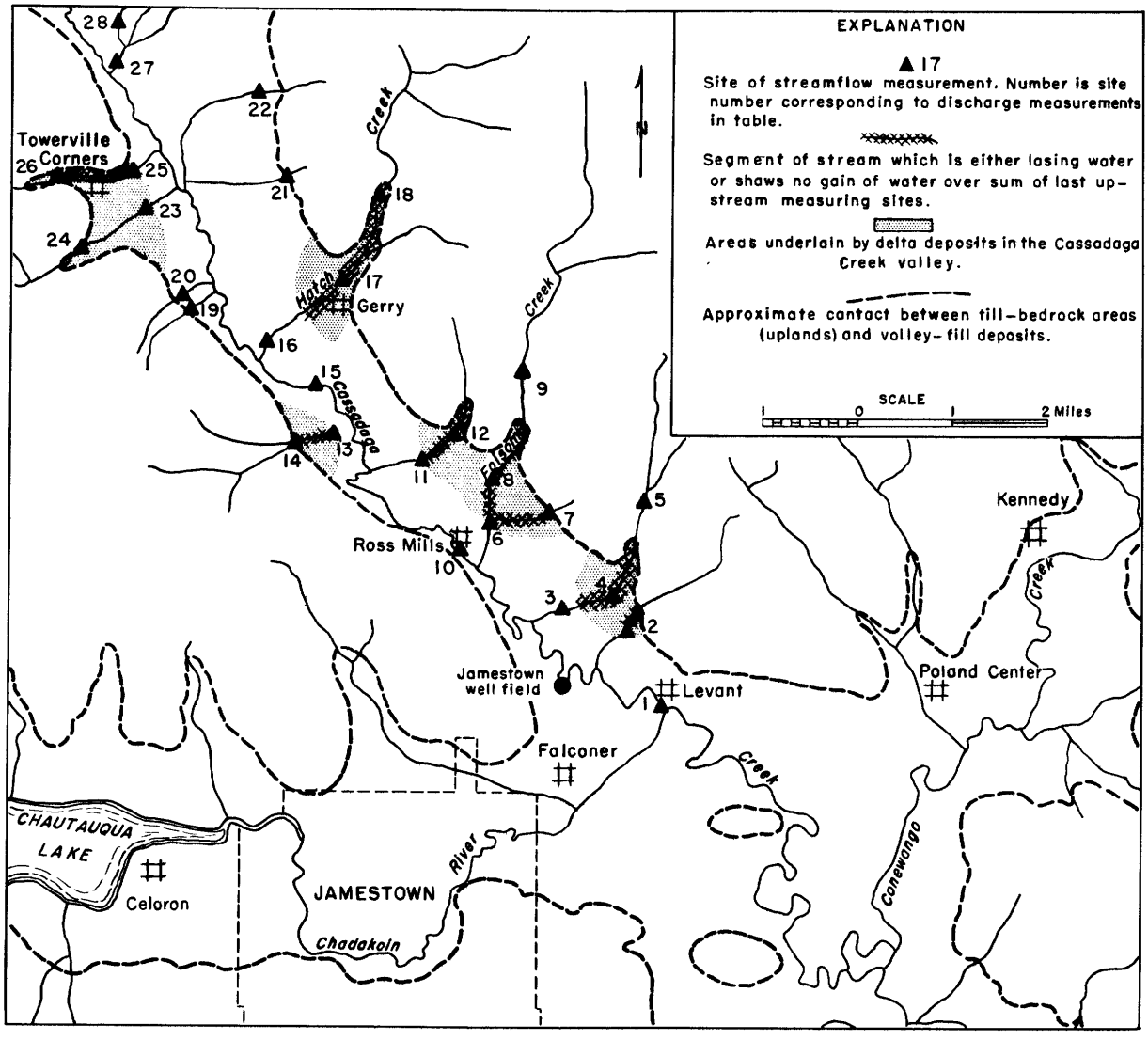


Figure 20.--Areas of the Cassadaga Creek valley underlain by delta deposits, location of stream segments losing water, and location of streamflow measuring sites.

The solution of the water-budget equation for the delta of Folsom Creek involves certain assumptions. The values used in solving the equation for April 1964, and the assumptions that were made are as follows:

1. Precipitation - Precipitation at the Jamestown station in April was 4.07 inches. Although this station is about 4 miles south from the delta it is assumed to represent precipitation on the delta. The precipitation was remarkably evenly distributed during the month. In computing the total amount of precipitation on the delta, an area of 0.4 square mile was used.

2. Change in ground-water storage - There was no significant change in the water levels in wells 209-913-12 and 210-912-2 for the entire month. It is, therefore, assumed that no change in ground-water storage occurred.

3. Streamflow into and out of the delta - Only one series of streamflow measurements were made, those of April 27. The average inflow for the month, therefore, is not known and can only be approximated by correlation with other streams. Because the mean monthly discharge for Conewango Creek at Waterboro was about 935 cfs during April, and the flow at that station was about 470 cfs on April 27, it seems safe to assume that the flow of Folsom Creek to the delta averaged about twice that measured on April 27. However, because ground-water levels in the delta remained constant during the month (fig. 21), streamflow crossing the delta was obviously far in excess of that streamflow being infiltrated to make up for any other losses. Therefore, during the month the streamflow that is important in the present consideration is that which was being lost to the delta. It may be assumed that this loss of streamflow to the delta was at a fairly constant rate during the month, regardless of the total streamflow. As long as the water level in the delta was stable, any of the excess streamflow was merely discharged by peripheral discharge. Therefore, in computing losses to the delta, the April 27 measurements were used because the error introduced is probably not large.

4. Evapotranspiration losses - Evapotranspiration losses were computed by the Thornthwaite method (Thornthwaite, 1948) to be 1.6 inches of water.

Converting the values for precipitation and evapotranspiration losses to cubic feet per second and substituting the values of streamflow for sites 6, 7, 8, and 9 from table 2 into the equation, the subsurface discharge is computed as follows:

$$D_a = P + I - D_s - ET \pm \Delta S$$
$$D_a = 1.4 \text{ cfs} + 4.8 \text{ cfs} - 3.7 \text{ cfs} - 0.6 \text{ cfs} \pm 0.0 \text{ cfs}$$
$$D_a = 1.9 \text{ cfs (or 1.2 mgd)}$$

This computation indicates that 1.2 mgd of water was being lost by subsurface seepage from the Folsom Creek delta during April. This loss could either represent surface outflow around the periphery of the delta or seepage into the Jamestown aquifer. Because of the high water table in the delta in April, it is probable that at least some of this loss was through peripheral discharge.

A similar computation was made for May 1964. The streamflow at site 9 was measured on both May 7 and May 18. These measurements were correlated with changes in ground-water level in order to estimate the average monthly streamflow. Precipitation at Jamestown during May was 2.59 inches. The ground-water level declined about 5 feet during the month. In arriving at values for changes in ground-water storage, it was assumed that the average change in water level of wells 209-913-12 and 210-912-2 represents the average change in the entire delta. It was also assumed that for each cubic foot of delta dewatered, 0.2 cubic foot of water was released from storage. Substitution of the values in the water-budget equation yields a subsurface discharge for May of 5.1 cfs (3.3 mgd). The subsurface discharge for June was also computed and found to be 6.8 cfs (4.3 mgd).

The values cited above show that the subsurface discharge from the Folsom Creek delta increased from about 1.2 mgd in April to about 4.3 mgd in June. As noted earlier, this discharge could represent either evapotranspiration losses from the delta, surface seepage around the periphery of the delta, or discharge to the Jamestown aquifer. Losses by evapotranspiration were accounted for in the above computations and can, therefore, be eliminated from further consideration. The subsurface discharge must then be accounted for either through surface seepage or discharge to the aquifer.

In April the water table in the delta was at its seasonal high position (fig. 21) and the water table sloped toward the center of the valley. (See the water-table profiles in figure 18.) Because of this gradient and the relatively high position of the water table, it is possible that peripheral discharge was occurring. In June, however, the average water table was 14 feet below its April position, and the gradient toward the valley was considerably less than that of April. The subsurface discharge, on the other hand, was 3.5 times the April discharge. Clearly, this loss cannot be accounted for in any way except through discharge to the Jamestown aquifer because peripheral discharge must be directly proportional to the height of the water table and to the water-table gradient and, therefore, must have been considerably less in June than in April. In fact, it appears safe to assume that no peripheral discharge was occurring in June and that all the subsurface discharge of 4.3 mgd was entering the Jamestown aquifer.

Figure 21 shows hydrographs of the daily lowest water levels in four wells. Two of these wells (209-913-12 and 210-912-2) are located in the Folsom Creek delta. The other wells (209-913-1 at Ross Mills and 208-912-16 at the well field) tap the Jamestown aquifer. The geologic and topographic positions of three of the wells (excepting 208-912-16) are shown in figure 18. The water levels in all of the wells are plotted below a common assumed datum so that the water levels in the wells may be compared directly. The two periods of record shown reflect both fall and spring conditions.

The effects of recharge and discharge upon water levels in the delta and in the Jamestown aquifer may be analysed from these hydrographs. It should be noted that during the periods of no ground-water recharge when most water being discharged from the delta was derived from storage, the water level in well 210-912-2 near the head of the delta declined to a lower altitude than that in well 209-913-12 (September 1962 and 1964). The relative positions of the wells (fig. 18) with respect to Folsom Creek

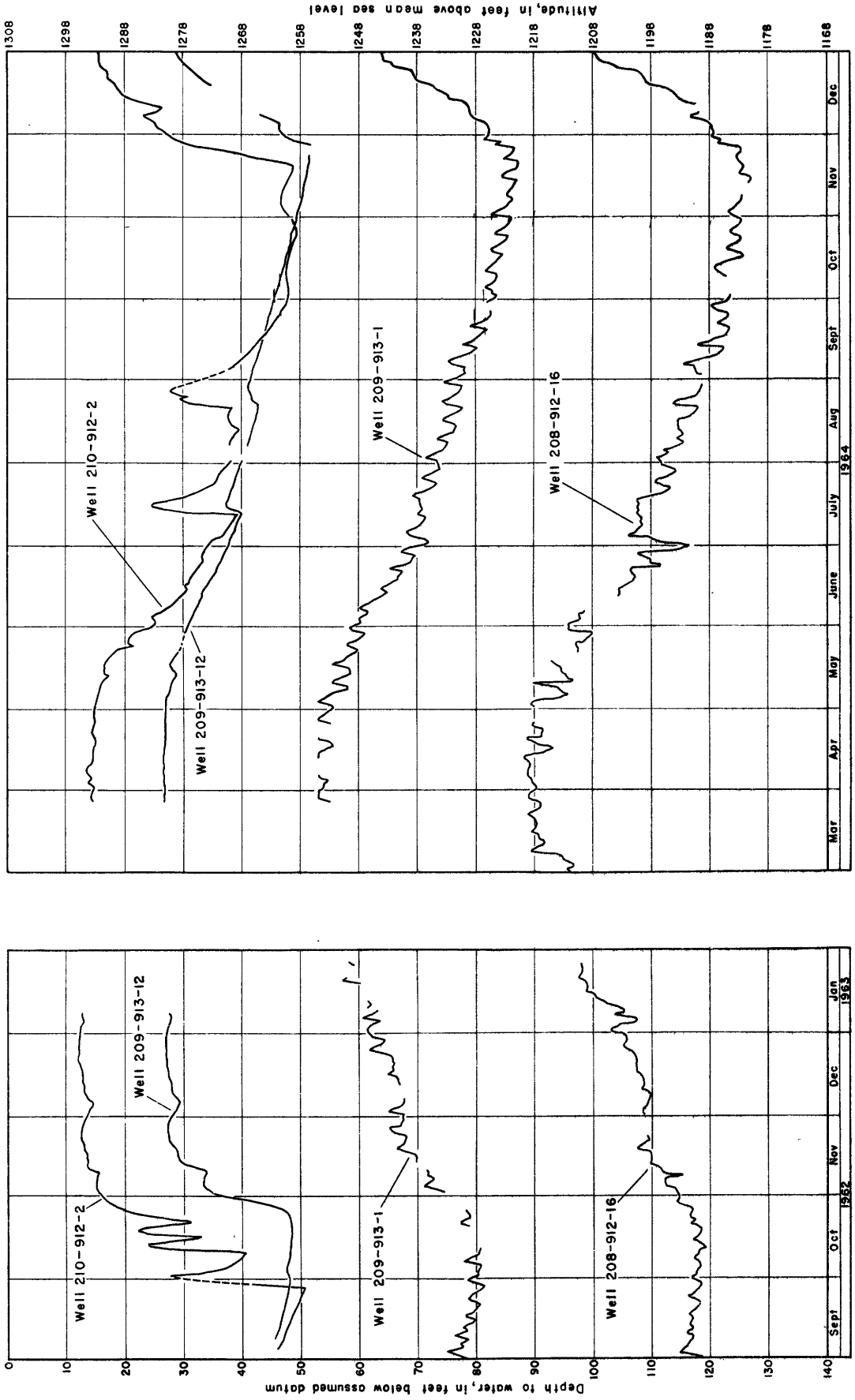


Figure 21.--Daily lowest water levels in wells 208-912-16, 209-913-1, -12, and 210-912-2.

indicate that just the opposite should be true. The significance of this reversed relationship will be discussed in a following paragraph.

As the first fall "flood" came down Folsom Creek in September 1962, it caused an immediate and steep rise in the water level in well 210-912-2. At the same time, the water level in the Jamestown aquifer at Ross Mills (well 209-913-1, fig. 21) began to rise slowly while in well 209-913-12, located near the periphery of the delta, it did not begin to rise for about a month. This lag of one month is the time required for the excess streamflow from Folsom Creek to replace the storage in the delta which had been depleted during the summer.

After the storage in the delta was replaced, about November 1962, the water levels in the wells in the delta and those in the Jamestown aquifer fluctuated together and maintained a fairly constant head relationship. In May 1964, the water levels in both the delta and the Jamestown aquifer began to decline at nearly the same rate.

It should be noted that the actual water-table gradient in the delta cannot be determined solely on the basis of measurements in wells 209-913-12 and 210-912-2. At best, these wells only indicate an "apparent" gradient. The water table undoubtedly sloped toward the periphery of the delta in April and June 1964, though not necessarily at the slopes indicated in figure 18. The September 1962 measurements show an apparent gradient in the opposite direction. This gradient suggests a movement of water from the periphery toward the valley wall. However, because the valley wall is composed of till over bedrock, both of which are relatively impermeable, it is obvious that the water is not moving toward the valley wall but, instead, is moving toward the part of the delta that directly supplies water to the Jamestown aquifer. The geologic data in figure 18 suggests that the hydraulic connection between the delta and the aquifer is between wells 209-913-12 and 210-912-2. Therefore, the water table at the wells in September 1964 probably slopes toward an area between the two wells. As suggested by figure 18 and by the lower water level in well 210-912-2, this area is probably closer to that well than to well 209-913-12.

Figure 22 represents an idealized version of the Cassadaga Creek valley in the vicinity of Folsom Creek. Although somewhat exaggerated, the relationship between the Jamestown aquifer and the delta is that which was shown by the geologic and hydrologic data discussed in the preceding pages.

Data on ground-water temperatures in the delta deposits were also collected during the course of the investigation to supplement the geologic and water-level data. Figure 23 shows profiles of water temperature in wells 209-913-12 and 210-912-2 at different times during the investigation. In each profile the uppermost measurement was made just below the water level at that time. Although all of these measurements were not made during the same year or often enough to determine extreme ranges of water temperature, they do represent spring and fall conditions when the temperatures were near the extremes. The seasonal range of water temperature near the water table in well 209-912-12 is 8°F but is only about 1°F below 40 feet. In contrast, the range of temperature of water in well 210-912-2 is as much as 18°F and shows no relationship to depth.

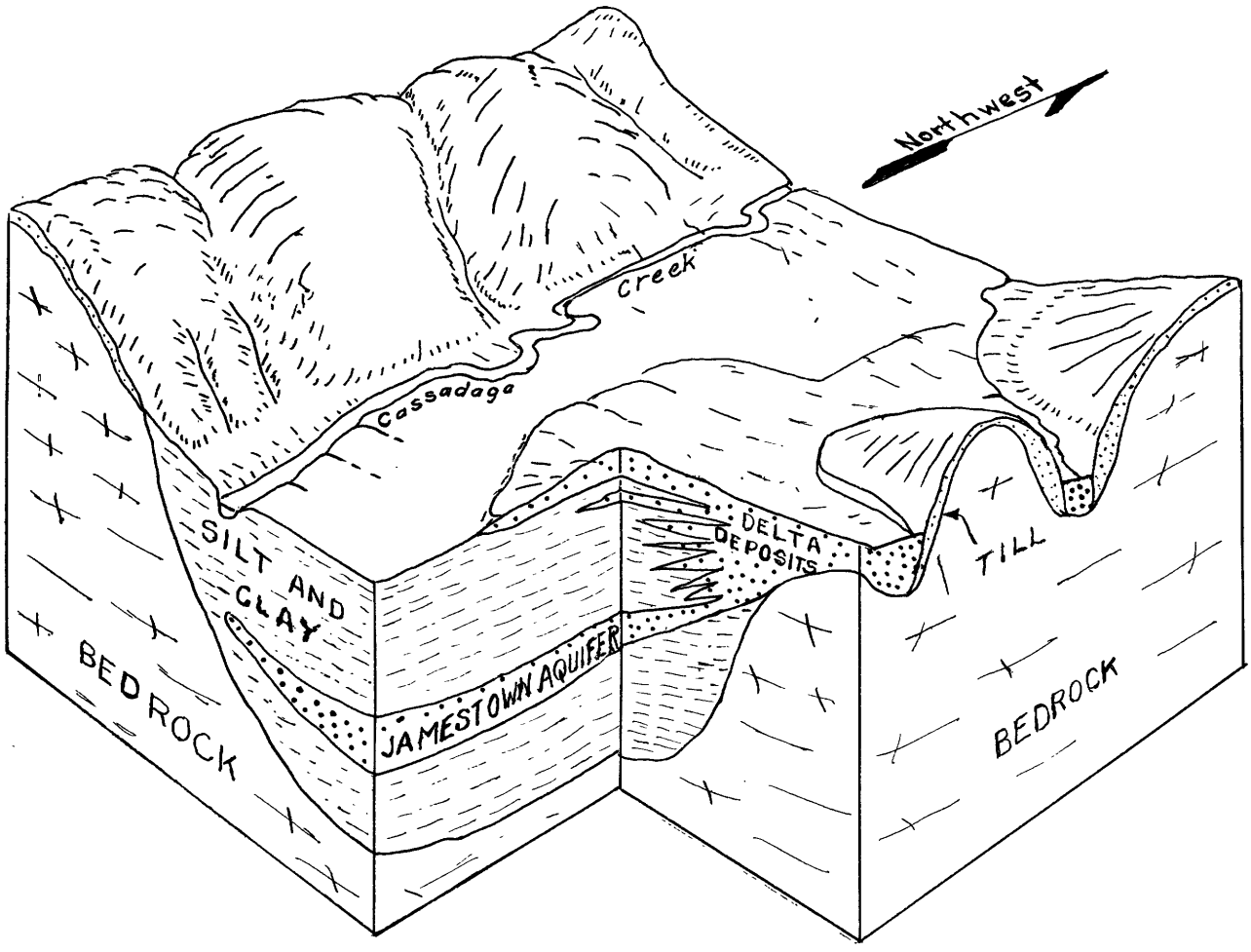


Figure 22.--Cassadaga Creek valley in the vicinity of Folsom Creek.

The temperatures in well 209-913-12 are very similar to the normal ground-water temperatures which would be expected in the area. (See the discussion of ground-water temperature in the section devoted to Quality of Water.) In effect, the temperature of the water is relatively constant below a certain depth due to the tempering influence of the aquifer and the slow rate of ground-water movement.

However, the temperatures in well 210-912-2 show a large fluctuation of temperature. This fluctuation is caused by the movement of large volumes of water from Folsom Creek into the delta deposits to replace the water that has moved into the Jamestown aquifer. The temperature profile of April 29, 1964, shows the effect of recharge during March and April when the water in Folsom Creek is only slightly above freezing. The profile of October 12, 1962, reflects the infiltration of much warmer water during the late summer and early fall.

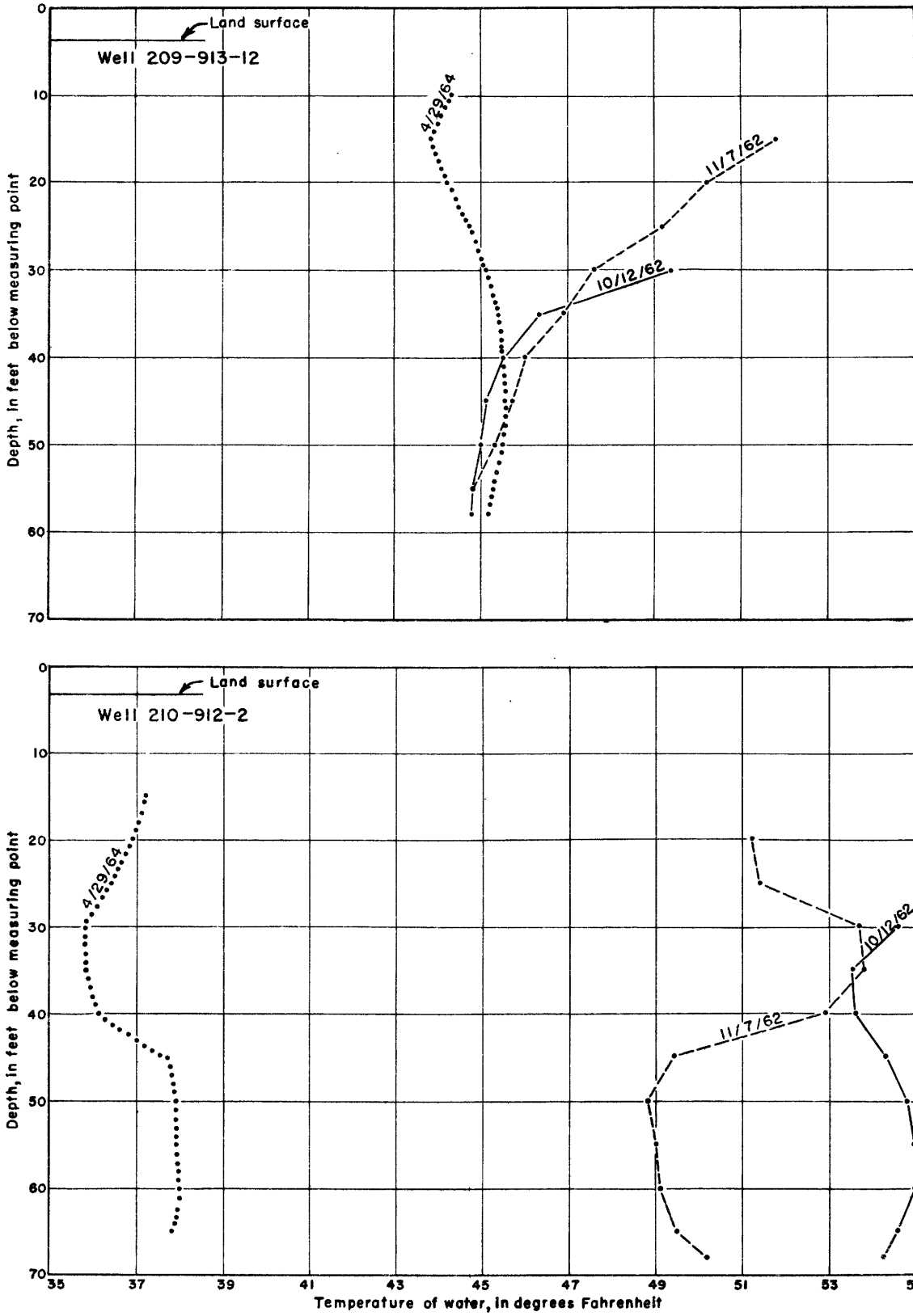


Figure 23.--Profiles of water temperature in wells 209-913-12 and 210-912-2.

Ground-water movement

The principal movement of water in the aquifer, as has been pointed out in the preceding discussions, is from the deltas to the Jamestown well field. The direction of movement in different parts of the aquifer can be determined from figure 24 which shows the altitude of the piezometric surface of the aquifer on June 7, 1963, when the well field was being pumped at a rate of approximately 6.5 mgd. All of the measurements shown in the figure were made at approximately the same time to determine the shape of the piezometric surface under fairly stable conditions. The altitudes of the measuring points used in determining the water levels in the Jamestown well field at Levant, and at the southernmost well at Ross Mills, are based upon precise levels. All of the other altitudes were measured with a barometric altimeter and are accurate to plus or minus a couple of feet.

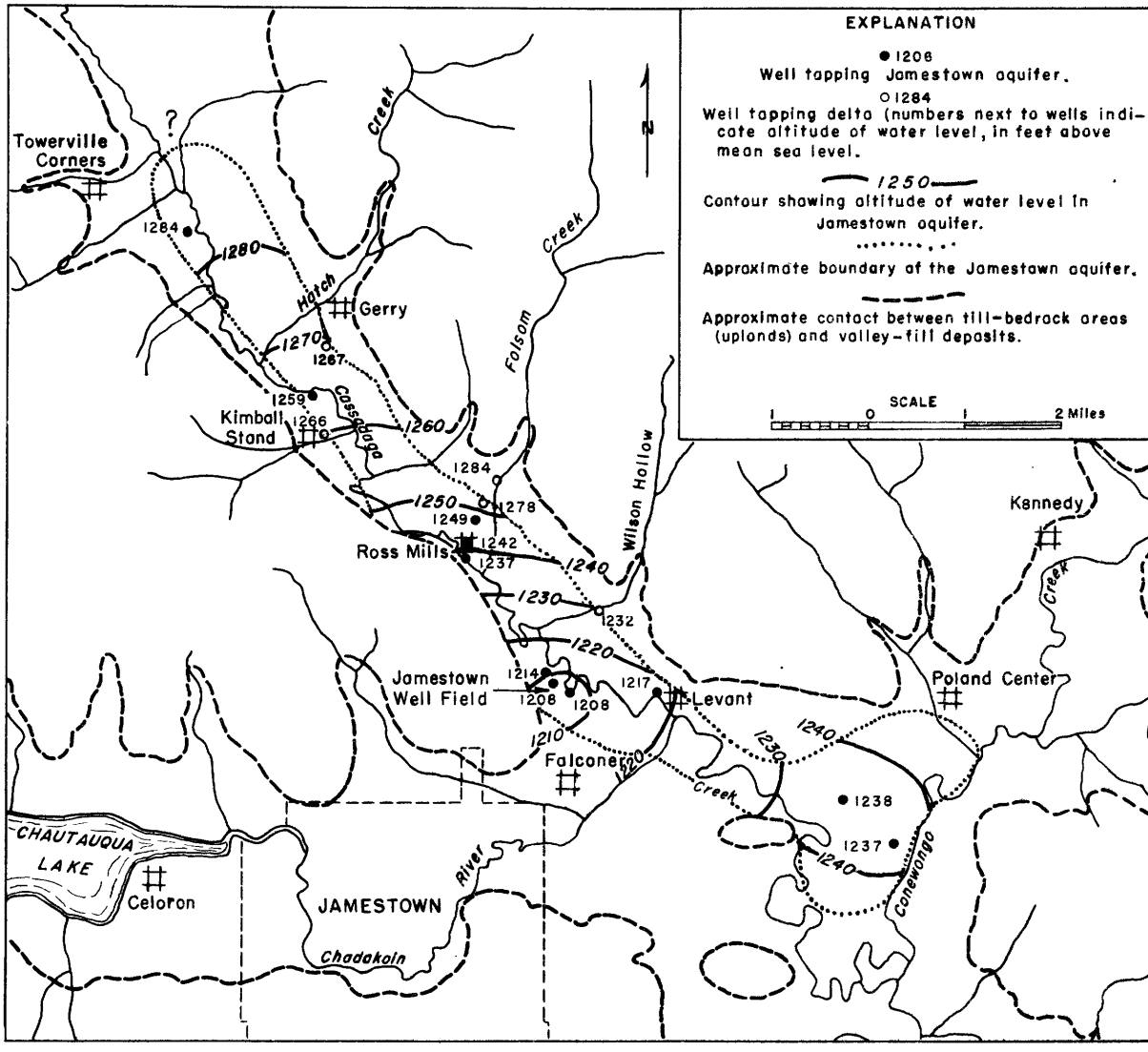


Figure 24.--The altitude and configuration of the piezometric surface of the Jamestown aquifer on June 7, 1963.

It should be noted that the altitudes of water levels measured in the deltas are higher than the altitude of the piezometric surface in the Jamestown aquifer. This reflects the head lost as water moves from the deltas into the Jamestown aquifer. For this reason the wells in the deltas were ignored in drawing the contours and are merely plotted to show the higher heads in the deltas.

It may also be noted that the contours of the piezometric surface do not agree with the water level measured in the well in the Jamestown aquifer between Kimball Stand and Gerry. The water level in this well appears to be unusually low. The well flows and is located at a restaurant that was closed at the time of the measurement. The measuring point is located outside the building and the well is tapped below land surface to supply the restaurant. Because the water level in the well was considerably above land surface, this measurement was made with a pressure gage, and it is quite possible that there were leaks in the plumbing system or the well casing, or that a faucet in the building was not completely closed, resulting in low water-level measurement. Therefore, this water-level measurement was not considered in drawing the contours.

Water moves through the aquifer more or less at right angles to the contours on the piezometric surface in the direction of decreasing altitude. Thus, north of the well field water is moving down the valley toward the wells, whereas, southeast of the field it is moving up the valley.

The sloping surface of the piezometric surface around the well field is termed a cone of depression. A cone of depression is defined as the depressed surface of the water table (or of the piezometric surface of an aquifer) surrounding a pumping well or wells. It is formed by the withdrawal of water from storage in the aquifer in response to pumping, and its radial slope represents the gradient necessary to move water through the aquifer to the wells. The lowering of water levels is greatest around a pumping well and less as the distance away increases.

The rate of movement of water through an aquifer is of considerable interest in certain circumstances. For example, if a poisonous liquid were accidentally spilled on one of the deltas supplying the Jamestown aquifer, it would be important to know approximately when it would reach the well field.

The rate of movement of water through an aquifer is directly proportional to the permeability and the hydraulic gradient and indirectly proportional to the void ratio (porosity). These relationships may be expressed as:

$$v = \frac{P\ I}{7.5p}$$

where:

v = velocity in feet per day,
P = permeability in gallons per day per square foot,
I = hydraulic gradient in feet,
p = porosity, expressed as a decimal fraction,
7.5 = number of gallons in a cubic foot.

To illustrate the application of this equation to the Jamestown aquifer a trial computation can be made for the part of the aquifer from Ross Mills to the well field. The permeability is known to be about 8,500 gpd per square foot at the Jamestown well field (see following section), the hydraulic gradient declines about 30 feet in the 7,900 feet from Ross Mills to the well field, and the porosity is assumed to be about 30 percent (0.30). Substitution of these values in the equation gives a velocity of about 14 feet per day.

This value is, at best, only a rough approximation of the actual velocity. Depending on permeability, hydraulic gradient, and porosity, and other related factors such as stratification, the actual velocities in the aquifer probably range from a few feet per day in some parts to several tens of feet per day in other parts.

Hydraulic characteristics

The capacities of an aquifer to store and to transmit water are referred to as hydraulic characteristics. The two most important of these characteristics are the transmissibility and the storage coefficient. The coefficient of transmissibility is the rate of flow of ground water at the prevailing water temperature, in gpd, through a 1-foot wide vertical strip of an aquifer under a hydraulic gradient of 1 foot per foot. For convenience, the coefficient of transmissibility will be referred to simply as transmissibility in this report. The storage coefficient may be defined as the amount of water that will drain from a vertical section of an aquifer with a base area of 1 square foot when the water level (or hydraulic head) is lowered 1 foot.

These characteristics are usually determined by analysing the drawdowns produced in observation wells when a production well is pumped at a constant rate. The Jamestown well field includes both production wells and observation wells (fig. 17). However, the pumping schedule of the city and the relative location of the wells were such that it was not possible to make an acceptable test in the well field area. It was, therefore, necessary to analyse the water-transmitting capacity of the aquifer from the data shown in figure 24.

The piezometric surface in figure 24 is based on measurements made on a Friday (June 7, 1963) after the well field had been pumping at an essentially constant rate of 6,500,000 gpd for 5 days. It may, therefore, be assumed that the rate of decline of water levels was the same throughout a large area in the vicinity of the well field; in other words, a steady-state condition existed. Under such a condition the flow of water through the aquifer is controlled by Darcy's Law which, expressed in terms of an aquifer, is:

$$Q = TIW$$

where:

Q = the quantity of water, in gallons per day, moving through the aquifer (i.e., the pumping rate),
T = the transmissibility of the aquifer in gallons per day,
I = the hydraulic gradient in feet, and
W = the width of the aquifer in feet.

The hydraulic gradient and the width of the aquifer can be determined from figure 24. The pumping rate was noted above. Therefore, the transmissibility of the aquifer can be calculated by rearranging the terms in the preceding equation. It should be noted first though, that water is converging on the well field from both the northwest and southeast and the gradients and aquifer widths differ in each direction. This requires modification of the equation as follows:

$$T = \frac{Q}{IW}$$

$$T = \frac{Q}{(IW)_{NW} + (IW)_{SE}}$$

where the subscripts NW and SE refer to the two segments of the aquifer mentioned above. Solving the equation using the gradients between the 1,220-foot and 1,230-foot contour lines both northwest and southeast of the well field, and the width of the aquifer between these lines yields:

$$T = \frac{6{,}500{,}000}{\left(\frac{10}{2{,}100} \times 7{,}920\right) + \left(\frac{10}{7{,}400} \times 3{,}700\right)} = 151{,}000 \text{ gpd per foot}$$

The permeability of an aquifer is equal to the transmissibility divided by the saturated thickness. The thickness of the Jamestown aquifer in the vicinity of the well field ranges from 15 to 20 feet. Dividing each of these thicknesses into the transmissibility and averaging the answers gives a permeability of about 8,500 gpd per square foot.

It may be noted, in passing, that the products of gradient and width substituted in the above equation also show the relative yield of the two segments of the aquifer. The northwest and southeast products are 38 and 5, respectively. If it is assumed that the permeabilities and aquifer thicknesses are the same along both of the lines selected for the gradient and width determinations, these products indicate that about 90 percent of the yield of the well field is derived from the northern part of the valley and the remaining 10 percent from the southeast. These values are consistent with the data on the recharge areas.

The deflection of the water-level contours around the Folsom Creek and Wilson Hollow deltas indicates that much of the pumpage derived from the area northwest of the well field is derived from these two deltas. It is also apparent from the contours in figure 24 that a substantial part of the yield is supplied by water moving down the Cassadaga Creek valley, from the area north of the Folsom Creek delta, in response to the regional gradient in the aquifer.

It is not possible to determine the storage coefficient of the aquifer from the data available. However, the relatively rapid decline of the water level in the observation wells following the start of pumping suggests a rather small artesian storage coefficient, one possibly in the range of 0.001 to 0.0001. (See figure 19.)

Summary of aquifer hydrology

Under natural conditions, prior to the construction of the Jamestown supply wells, water moved through the aquifer from the deltas and discharged by upward seepage throughout most of the valley bottom. Because of the extremely low permeability of the confining bed, the rate of seepage was very small. Because of the small natural discharge from the aquifer, most of the water entering the deltas was lost by surface seepage around the fringes of the deltas and by infiltration to the streams crossing them.

The first supply well reduced the artesian pressure and stopped all leakage in the vicinity. If the pumping had been held at a constant rate of a few hundred gallons per minute, it is possible that the cone of depression would have stabilized before it reached the nearest delta. In other words, the withdrawals would have been supplied by salvaged discharge.

The withdrawals obviously could not be held constant because of the increasing need for water and have, in fact, shown a steady increase over the years. As the pumpage increased, the cone of depression expanded, doubtless first into the delta built by the small stream draining Wilson Hollow. It may be reasoned that the cone of depression did not expand beyond this delta so long as the inflow into the aquifer from the delta equaled the pumping rate. Regrettably, this rate cannot be determined from the data now available. Further increase in withdrawals resulted in an expansion of the cone of depression into the delta of Folsom Creek and gradually up the valley above Folsom Creek. Each increase in pumpage was, of course, accompanied by an expansion of the cone into the area southeast of the well field. However, for the sake of simplicity, this discussion is limited to the area northwest of the field.

During the fall and winter a large part of the precipitation on the uplands adjoining the Cassadaga Creek valley runs off over the land surface to the small tributary streams that drain the uplands. The water flows down these streams and infiltrates into the delta deposits to replace the storage depleted by the previous summer's pumpage. After the storage is replenished the excess streamflow continues across the deltas to Cassadaga Creek. By the end of the spring runoff period, the deltas are full and pumpage is being supplied by water infiltrating into the deltas from the streams. Gradually, as the streamflow diminishes, water is withdrawn from storage to make up the deficit between pumpage and stream infiltration.

The relationship between the Jamestown aquifer, the deltas, and pumping at the Jamestown well field may be simplified as shown by the hydrologic model in figure 25. This model compares the Jamestown aquifer to a pipeline connected to a series of reservoirs (the deltas).

The figure demonstrates what the system would look like during the summer. As pumping continues at the well field during the summer, the inflow to the delta-reservoirs is not sufficient to supply the water. Therefore, the storage in the deltas is used to supply the water. This also causes the pumping level at the well field to decline as the gradient necessary to deliver the same rate of flow through the aquifer (pipeline) must be maintained.

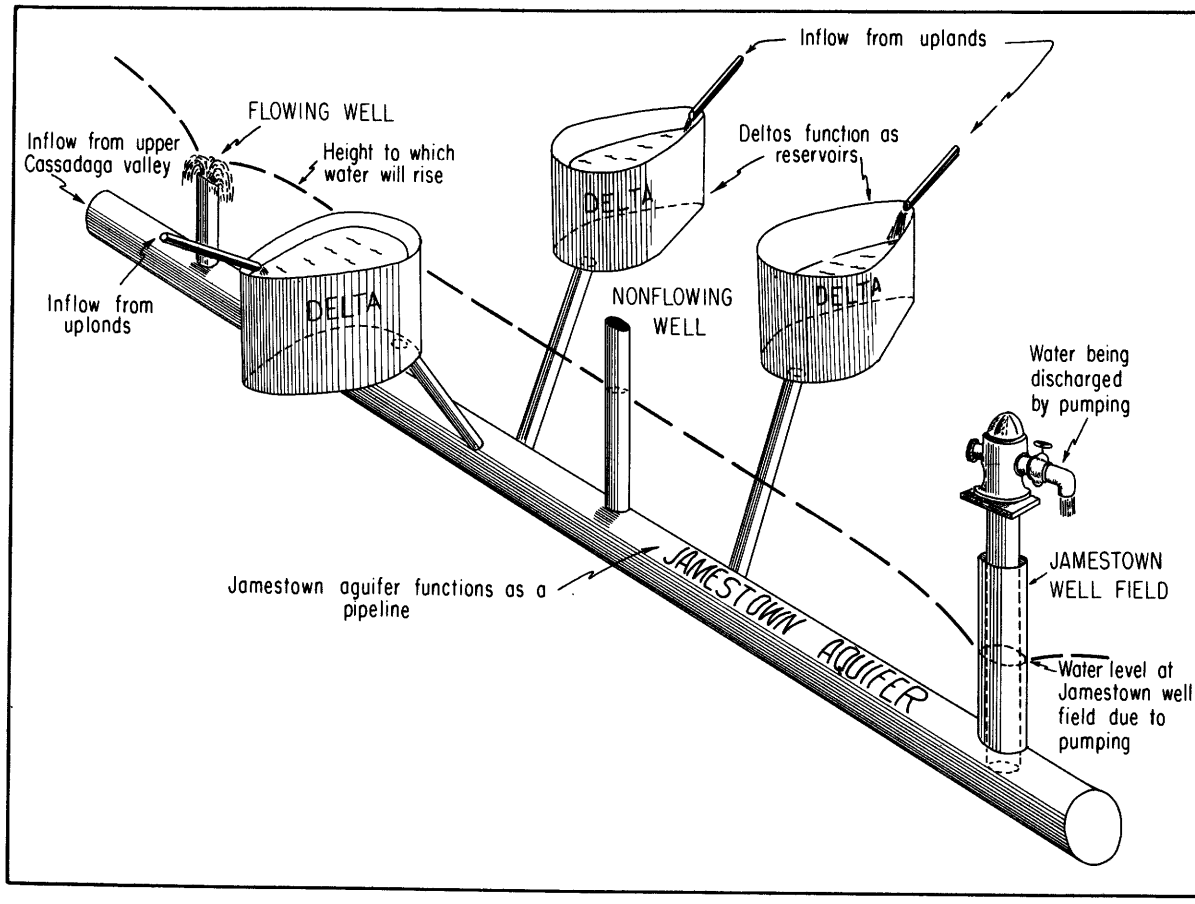


Figure 25.--Relationship between the Jamestown aquifer and the deltas of streams tributary to Cassadaga Creek.

During the winter or spring, the deltas would have more inflow than outflow and be overflowing. At this time the gradient shown in figure 25 would adjust itself upward in accordance with the higher head of water in the deltas.

Yield

As noted at the beginning of this report, one of the principal objectives of the investigation was to determine the perennial yield of the Jamestown aquifer. Because of the city's dependence on the aquifer for its water supply, the perennial yield is obviously of great importance in the city's long-range plans.

The perennial yield of an aquifer may be defined as the maximum rate at which water can be withdrawn from the aquifer under the most adverse climatic conditions. The perennial yield of the Jamestown aquifer is dependent on three factors. These are:

1. The capacity of the aquifer to transmit water from recharge areas (the deltas) to the well field,

2. The rate of recharge to the deltas by precipitation and stream infiltration, and

3. The quantity of water in storage in the deltas which can be drawn on during times when the rate of recharge is inadequate.

Relationship of yield to hydraulic gradient.--The capacity of the aquifer to transmit water is controlled by Darcy's Law which was discussed in the preceding section on hydraulic characteristics. Darcy's Law relates the quantity of water (Q) moving through an aquifer to the transmissibility (T), the hydraulic gradient (I), and the width of the aquifer (W). Of these factors (T) and (W) are constant along any cross section. Therefore, the quantity of water moving through any section of the aquifer is proportional to the hydraulic gradient. The maximum possible hydraulic gradient exists when the water levels in the pumping wells are pulled down to the top of the aquifer. (Below this the aquifer is physically dewatered and the transmissibility decreases.)

The relationship of aquifer yield to hydraulic gradient is shown in figure 26. This figure contains a series of solid lines originating at a point designated as "A." Each line is labeled with a pumping rate "Q" (i.e., 2, 6, 10, and 30 mgd). It may be noted that the slope of the lines and, therefore, the drawdowns at the well field increases in direct proportion to "Q." The hinge point "A" for these lines is located 5,000 feet from the line designated as the center of the Jamestown well field. This distance was selected because it represents the distance from the well field to the center of the delta built by the stream draining Wilson Hollow. The dashed lines in figure 26 show the gradient that would exist in the aquifer if all the water were being derived from the delta at Towerville Corners (point B) at a distance of more than 36,000 feet from the well field. The hydraulic significance of these lines will be discussed in a succeeding paragraph.

The assumed static water level in figure 26 is believed to represent the approximate position of the average static water level prior to the start of withdrawals. This line is based on a water level 10 feet above land surface at the well field and 17 feet above land surface at Towerville Corners. The water level in well 212-916-1 at Towerville Corners ranges, at the present time, from 10 to 23 feet above land surface. The water level in this well is not believed to be affected to any great extent by present withdrawals. This line suggests a natural gradient down the valley of about 3 feet per mile. The movement of water down the valley in response to this gradient is about 600,000 gpd (0.6 mgd). This value is obviously an approximation, but is probably of the right order of magnitude.

The two sets of lines in figure 26 show that the maximum yield of any well field in the Jamestown aquifer depends on the distance to the recharge area. The closer the recharge area, the higher the yield. The Wilson Hollow delta is the closest area of substantial recharge to the present well field. The Towerville Corners delta, on the other hand, is believed to represent the effective outer limit that can be substantially influenced by the Jamestown well field. Therefore, the yield of the aquifer at the well field would be about 5 mgd if all the water pumped were derived from the Towerville Corners

delta (and from the area northwest of the delta). The yield would be more than 30 mgd if all the water, except the 600,000 gallons that moves down the valley under the natural gradient, were derived from the Wilson Hollow delta.

The recharge to the aquifer through the Wilson Hollow delta is obviously considerably less than the present pumping rate of 6 mgd, as indicated by the substantial recharge that occurs through the delta of Folsom Creek and the other deltas between Folsom Creek and Towerville Corners. Therefore, it may

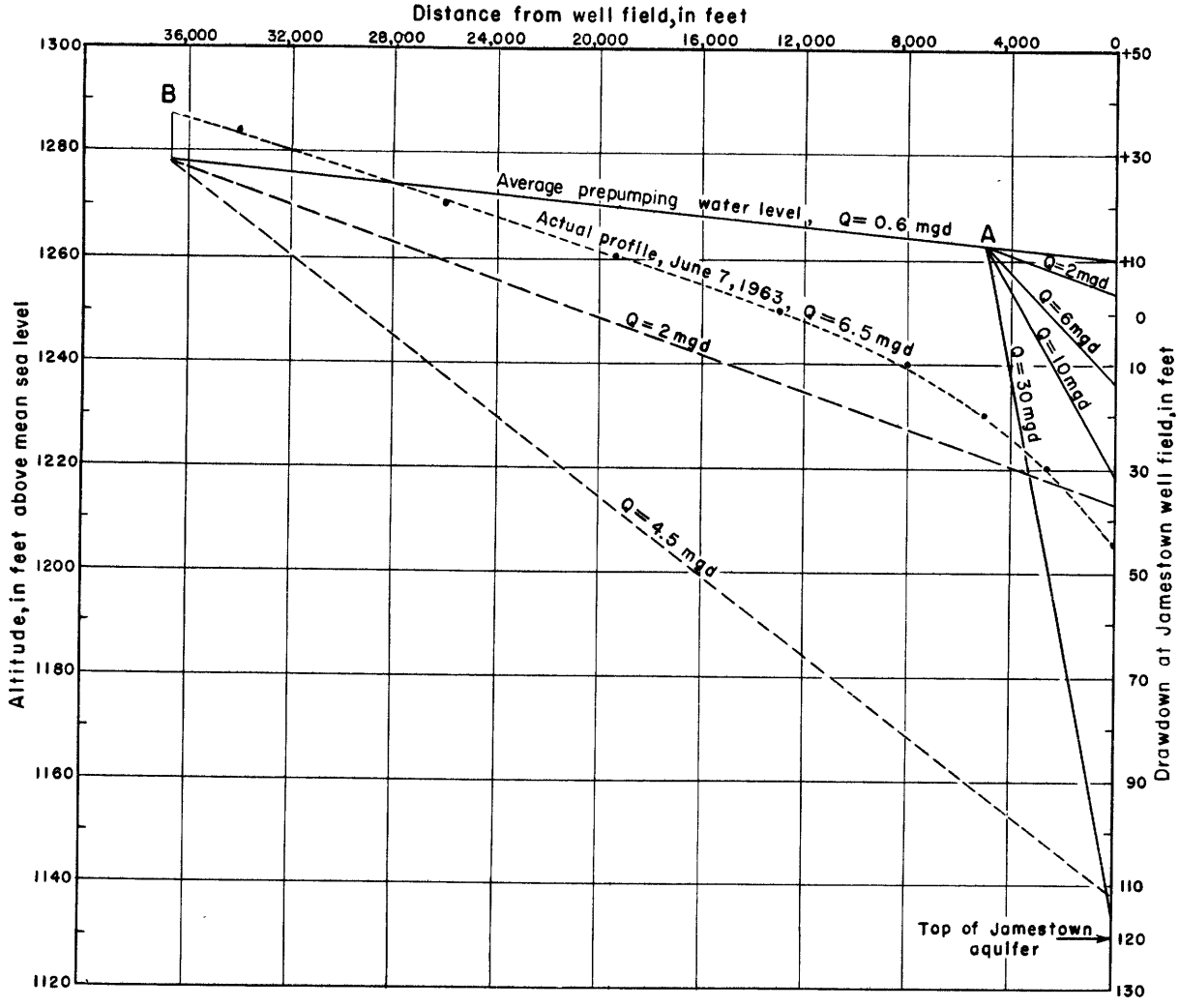


Figure 26.--Computed profiles of water levels in the Jamestown aquifer at different pumping rates, and the actual profile on June 7, 1963. The solid lines are based on the assumption that all pumpage is derived from point A, 5,000 feet from the well field. The dashed lines are based on the assumption that all pumpage is derived from point B, more than 36,000 feet from the well field.

be concluded that, so far as the ability of the aquifer to transmit water is concerned, the maximum perennial yield at the site of the present well field is more than 6 mgd and probably less than 30 mgd. It should be emphasized at this point that the water-level gradient lines drawn from points A and B in figure 26 assume that ground-water levels remain constant at those points (i.e., there is no depletion of storage). This assumption is, of course, contrary to fact but was made to demonstrate the relationship between yield and the aquifer's ability to transmit water.

The actual profile of the water level in the Jamestown aquifer on June 7, 1963, is shown in figure 26 for comparison with the computed profiles. It may be observed that the slope of this profile near the well field is nearly the same as that from point A for a Q of 6 mgd. The upper portion of the profile is nearly parallel to the 2 mgd line that originates at point B. The June 7 profile indicates that nearly all of the 6.5 mgd of pumpage is being derived from the valley area northwest of the well field and that of this amount about 2 mgd is being derived from the Towerville Corners delta and the area beyond.

Figure 27 shows the actual profile of the water levels on June 7, 1963, along with the seasonal high and low profiles for that year. The distance to the different deltas from the well field is also shown. The pumpage rates shown are 90 percent of the average daily rate during the period of continuous pumpage immediately prior to the time of the water-level measurements. The period of continuous pumpage was about 4 days in each case. The remaining 10 percent of the pumpage is assumed to be derived from the area southeast of the well field.

Relationship of yield to delta recharge.--The second and third factors affecting the perennial yield of the Jamestown aquifer - that is, the rate of recharge to the deltas and the amount of water in storage in the deltas - are so interrelated that it is difficult to discuss them separately. It is known that pumpage during the summer depletes the storage in the deltas. In the fall recharge from precipitation on the deltas and streamflow from the adjoining uplands replenishes the storage, and during the remainder of the fall and the winter the pumpage is supplied by water that infiltrates downward from the surface of the deltas or from the streams crossing the deltas. With the advent of plant growth and high evaporation losses in the spring, the ground-water recharge and the flow of the streams draining the uplands begin to decline. In late April or May, the ground-water recharge and the streamflow available for infiltration become inadequate to supply the pumpage, and water is drawn from storage in the deltas. The depletion of storage continues until the fall when recharge from precipitation on the deltas and infiltration of streamflow again replenishes the storage. The interrelationship of delta recharge and delta storage to the pumpage is shown in figure 28. It is not possible with the data available to indicate the vertical scale in the figure, and the reader should not attempt to do so.

The amount of water available on a yearly basis to recharge the deltas may be determined by multiplying the area of the deltas and the area drained by the streams crossing them by the average annual runoff per square mile. Obviously, the measurements made during the present investigation (table 2)

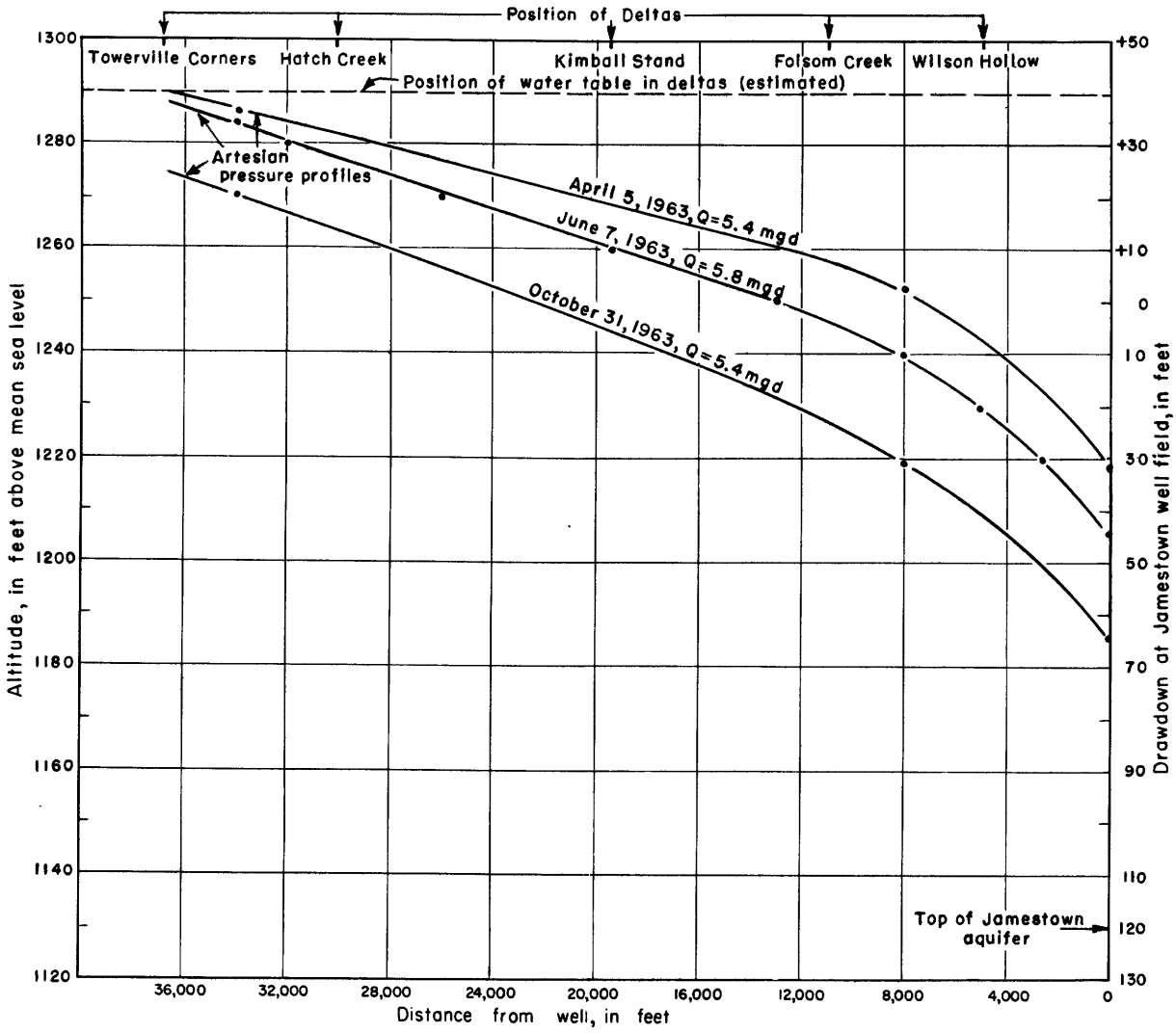


Figure 27.--Profiles of water levels in the Jamestown aquifer in 1963. The April profile represents the seasonal high and the October profile the seasonal low. Pumpage rates shown are 90 percent of the continuous pumpage for the period of about 4 days immediately prior to the time of the water-level measurements.

are too few to permit determination of the average annual runoff. However, long-term records are available for two stations in the area. The U.S. Geological Survey has maintained streamflow gaging stations on the Chadakoin River at Falconer and on Conewango Creek at Waterboro (pl. 1) for 28 and 25 years, respectively (U.S. Geol. Survey, 1963). The average discharge per square mile over these periods was 1.70 cfs for the Chadakoin River and 1.73 cfs for Conewango Creek. Because the Cassadaga Creek valley lies between the Chadakoin and Conewango valleys, the runoff per square mile in it may be estimated at about 1.7 cfs (1.1 mgd per square mile). The drainage areas upstream from the long-term gaging stations include several types

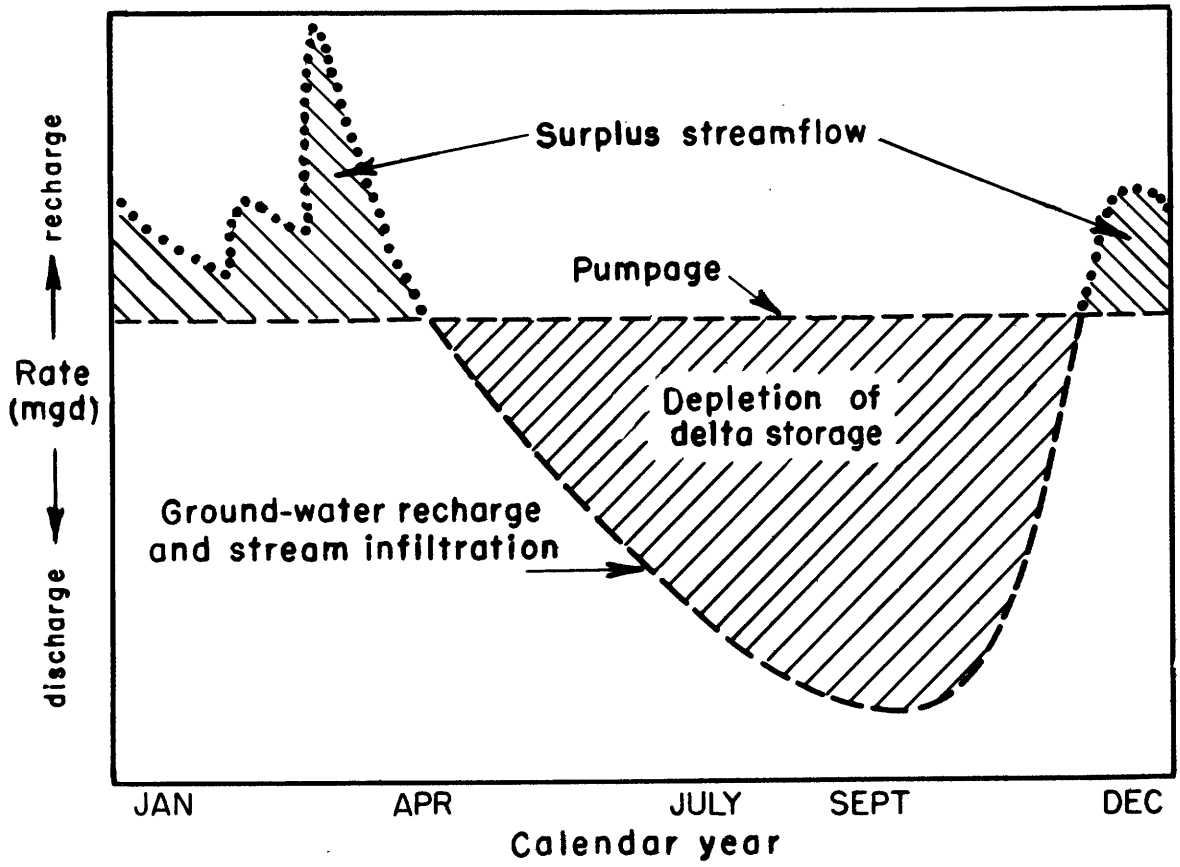


Figure 28.--Interrelationship of ground-water recharge, stream infiltration, delta storage, and pumpage.

of geology and topography. Actually, so do the smaller drainage areas of the tributary streams, including the deltas, as they drain both the till and bedrock uplands and the coarse-grained delta deposits. It is probably safe to assume, therefore, that the average discharge for the areas upstream from the periphery of the deltas would also be about 1.7 cfs per square mile or 1.1 mgd per square mile.

Table 3 lists the drainage areas of the tributary streams (fig. 20) from Wilson Hollow to Towerville Corners. This includes the area that supplies the major part of the present withdrawals and probably represents the extent of the area that can be effectively reached by the present well field. Multiplying the total drainage area by the factor of 1.1 mgd, it is determined that 31 mgd are available from this area to recharge the Jamestown aquifer. It should be noted at this point that the drainage areas listed in the table are those of the surface-water drainage areas. Thus, they include only a narrow strip of the deltas adjacent to each stream. If the entire area of the deltas had been included, the above figure would be somewhat larger.

The 31 mgd represents the average of the total annual runoff. Because of wide seasonal variations in runoff, it does not represent the amount of water available for recharge on a daily basis. This variation in streamflow can best be discussed in terms of streamflow-duration curves.

Table 3.--Drainage areas of selected tributary streams in the Cassadaga Creek valley

Site number (figure 20)	Stream	Drainage area (square miles)
2	Unnamed	0.8
3	(Wilson Hollow) stream	3.5
6	Folsom Creek	6.4
12	Unnamed	1.1
13	(Kimball Stand) stream	2.3
17	Hatch Creek	6.1
23	Unnamed	3.7
25	do.	4.3
	Total	28.2

Figure 29 shows the flow-duration curves for Conewango Creek at Waterboro (pl. 1) and Folsom Creek at site 9 (fig. 20). These flow-duration curves show the amount of streamflow, in gpd per square mile, which is equaled or exceeded for a certain percentage of the time. For example, the average discharge of Conewango Creek at Waterboro is 1.11 mgd per square mile. When this flow is located on the flow-duration curve, it falls at about the 31 percent point. This indicates that the flow of Conewango Creek exceeds 1.11 mgd 31 percent of the time. Sixty-nine percent of the time, it is less than this amount.

The flow-duration curve of Folsom Creek was constructed by correlating several measurements, made in 1962 and 1964, with the continuous record of flow on Conewango Creek. Because all of the measurements on Folsom Creek were made under base-flow conditions, only the lower half (below 50 percent duration) of the curve could be constructed by direct correlation. However, it may be assumed (as previously discussed) that the average annual discharge per square mile would be about the same as that of Conewango Creek.

With respect to variations in streamflow, it may be observed that the flow of Conewango Creek that is equaled or exceeded 10 percent of the time, which includes most of the winter and spring floods, is nearly 3 times the average annual runoff. At the other extreme, the flow that is equaled or exceeded 90 percent of the time is only one-tenth of the average annual runoff. Due to the relatively impermeable nature of the upland deposits and the steep hillslopes, the streams draining the uplands (such as Folsom Creek) are subject to even greater variation in streamflow. For example, the 90 percent duration point for Folsom Creek (23,000 gpd per square mile) is only about one forty-seventh of the assumed average annual discharge of 1.11 mgd. In other words, the flow of Folsom Creek after a long dry period is only one-fifth as much per square mile as Conewango Creek.

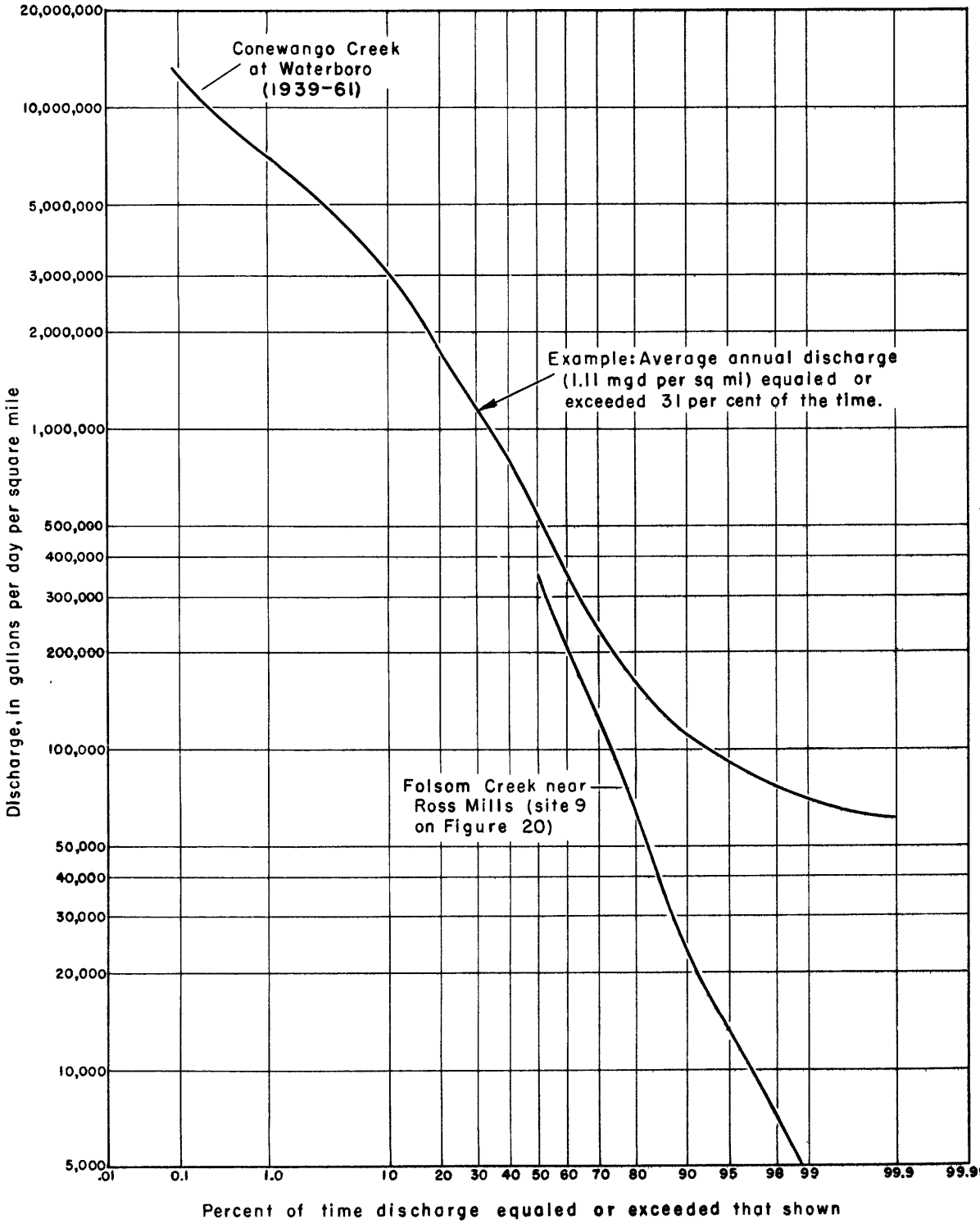


Figure 29.--Flow-duration curves for Conewango Creek and Folsom Creek.

It is apparent that the flow duration of the streams recharging the deltas has an important bearing on the amount of water available for recharge. Because these streams are characterized by very high discharges at the high end of the curve (representing spring runoff) and decline rather sharply toward the low end of the curve (representing summer flows), the quantity of water available for recharge to the deltas during the summer is only a tiny fraction of that available annually.

In summary, the average annual runoff of 31 mgd defines the total amount of water available to the Jamestown aquifer between the well field and the deltas at Towerville Corners. Much of this flow occurs during brief periods of heavy runoff. During the late spring, summer, and early fall, the streamflow available for recharge declines to only a small fraction of the average annual flow. One-tenth of the time, this flow is probably less than 600,000 gpd (23,000 gpd per square mile times 28 square miles).

Relationship of yield to delta storage.--During the period when streamflow is deficient, pumpage from the aquifer must be supplied from water stored in the deltas. Therefore, evaluation of the amount of water in storage is of considerable importance in the analysis of the perennial yield. Only meager information is available on the volume of permeable sediments in the deltas. This information suggests that the shape of the deltas very roughly resembles a distorted funnel. The size of the top of the funnel is roughly indicated by the areas in plate 1 underlain by deltaic deposits. The upper segments of the "funnels," as suggested by figures 18 and 22, are considerably larger than the lower parts.

Any computations of the volume of water in storage in the deltas is subject to large errors because of a lack of knowledge of their shape and size below the land surface. However, rough computations based on the assumption that the deltas are conical shaped and have a height equal to the distance from the water table to the top of the Jamestown aquifer may be informative. The volume of a cone is equal to:

$$V = \pi r^2 \frac{h}{3}$$

where "r" is the radius and "h" is the height.

In order to compute the volume of water in gallons stored in the deltas, this formula must be modified as follows:

$$V = 7.5\ A \frac{h}{3} S$$

where "7.5" is the number of gallons in a cubic foot, "A" is the area of the delta in square feet, "h" is the depth to the Jamestown aquifer in feet, and "S" is the storage coefficient of the deltaic deposits. The values for the area were determined by measuring the area underlain by deltaic deposits shown in plate 1. Because much of this area includes the thin outer fringes of the deltas, the actual measurements were reduced 50 percent to eliminate these fringes. Values for "h" were estimated by assuming that the water

table in the deltas at its seasonal high position is about 1,290 feet above sea level and subtracting the altitude of the top of the aquifer, as determined from figure 16, from this value. Because of the relatively coarse-grained nature of the deltaic deposits, the storage coefficient is assumed to be 0.2. The computations of storage using the preceding formula are listed in table 4 as "estimated total storage."

Because a hydraulic gradient is essential to transmit water from the deltas into the aquifer and then through the aquifer to the well field, all the estimated total maximum storage is not available because it is not possible to dewater the deltas to the top of the aquifer. Fortunately, however, because of the funnel (or inverted cone) shape of the deltas, the part dewatered first has the largest cross-sectional area.

The estimated available storage is also shown in table 4. In making this estimate, the profiles of the artesian pressure surface shown in figure 27 were utilized. It may be observed that the pumping rate was essentially the same at the times of the April and October profiles. The April profile represents the seasonal high water levels and the October profile represents the seasonal low. Therefore, the separation of the profiles represents the present amount of dewatering in the deltas supplying the aquifer. The values of available storage listed in table 4 assume that the lowering of water levels in the deltas that would occur under conditions of maximum development is twice the amount of the lowering in 1963.

The total maximum storage (table 4) amounts to about 3 billion gallons. This is adequate to sustain a pumping rate of 6 mgd for more than 500 days. The estimated available storage, on the other hand, is only about 1.7 billion gallons. This amount would sustain a pumping rate of 6 mgd for about 280 days and would sustain a pumping rate of 10 mgd for more than 160 days.

As a rough check on the validity of these figures, the amount of dewatering that occurred in 1963 was also computed and the values listed in the last column of table 4. These computations indicate that 944,000,000 gallons of storage was depleted between April 5 and October 31, 1963. The actual pumpage during this period was 1,219,274,000 gallons. A substantial part of the pumpage was obviously supplied by the flow of the streams crossing the deltas. The amount is not known but may have been about 10 percent of the pumpage. Another 10 percent of the pumpage was derived from that portion of the aquifer south of the well field. This leaves about 960,000,000 gallons to be accounted for by delta dewatering. The close agreement between the computed dewatering and the pumpage, though not expected, is probably still partly fortuitous. The close agreement does suggest that the computed value of estimated available storage is of the right order of magnitude.

The preceding discussions have considered the effect of aquifer transmissibility, recharge to the deltas, and storage of water in the deltas on the perennial yield of the Jamestown aquifer at the site of the present well field. These discussions have shown that the yield cannot exceed more than about 30 mgd. The actual perennial yield then is some value between the present withdrawals of 6 mgd and the maximum obtainable yield of 30 mgd. Because of a lack of precise data on both recharge and storage, further refinement of the yield value must be sought elsewhere.

Table 4.--Storage capacity of the deltas located between Wilson Hollow and Towerville Corners

Delta	Surface area 1/ (square feet)	Thickness of saturated section (feet)	Estimated total storage (gallons)	Potential dewatering 2/ (feet)	Estimated available storage (gallons)	Actual dewatering 1963 (gallons)
Wilson Hollow	8,300,000	120	496,000,000	68	400,000,000	240,000,000
Folsom Creek	11,200,000	140	784,000,000	60	528,000,000	304,000,000
Kimball Stand	2,800,000	150	209,000,000	48	112,000,000	64,000,000
Hatch Creek	11,200,000	150	840,000,000	40	392,000,000	208,000,000
Towerville Corners	8,300,000	170	704,000,000	32	240,000,000	128,000,000
		Totals	3,033,000,000		1,672,000,000	944,000,000

1/ Measured area on plate 1 reduced by 50 percent to eliminate thin outer fringe of deltas.

2/ Estimated amount of dewatering under conditions of maximum development.

Prediction of yield from past records.--During the course of the study, it was observed that the seasonal low water level in well 208-912-16 in the well field was declining fairly consistently year after year. Because the water level in this well must obviously include the integrated effect of the three factors affecting the yield, it seemed feasible to use the water-level data to determine a fairly reliable value for the maximum perennial yield. It was recognized, however, that a yield based on an extension of past data would be reliable only if supported by an analysis of aquifer transmissibility and delta recharge and storage.

Figure 30 shows the hydrographs of two wells from which the effects of climate may be differentiated from pumping effects of the Jamestown well field. Well 203-929-1 is located in a remote area approximately 10 miles west of Jamestown (pl. 2) and is not influenced by any pumping. Well 208-912-16 is located in the Jamestown well field (pl. 1) and reflects the drawdowns caused by pumping. It may be observed that the water-level fluctuations of these wells are very similar although the ranges of fluctuation are different. Annual high and low water levels and seasonal decline and recovery of water levels in the two wells correspond closely with respect to time. This indicates that both wells are influenced by approximately the same climatic conditions. Although the hydrograph for well 203-929-1 shows seasonal fluctuations due to natural recharge and discharge, there is no long-term decline of the water level indicated by the seasonal high or low water levels. Well 208-912-16, on the other hand, is affected by both climate and pumpage. The effect of pumpage is shown by the relatively consistent decline in both the seasonal high and the seasonal low water levels in this well. The dashed line on the hydrograph indicates the trend of the annual lowest water levels at the well field from 1953 to 1964. The fact that the seasonal low levels in both wells in 1956 and 1958 are much higher than usual, reflects unusually abundant precipitation and abnormal recharge during the summer. In the Jamestown aquifer this would be the time when most of the water being pumped would normally be derived from storage in the deltas. However, as a result of the summer recharge, the seasonal lowest water levels during these two years were significantly higher than normal and were not considered in drawing the trend line.

Figure 30b shows the annual average daily pumpage by the city of Jamestown, in millions of gallons, for the period 1953-63. This rate has gradually increased and the line drawn through the annual values shows the trend of the pumpage.

In figure 30c the two trend lines from graphs "a" and "b" are plotted against each other. The future decline of the water level at the well field due to pumping can be estimated from this graph. Because the top of the Jamestown aquifer at the well field is approximately 120 feet below land surface, this depth is the maximum permissible drawdown of water levels which will not result in a dewatering of the aquifer. Figure 30c shows that the trend line of the water level intersects the 120-foot water-level line at approximately 11 mgd.

It should be noted that the trend line of water levels in figure 30a is an average and that the actual annual lowest water levels may fall either a few feet above or below the line. It should also be noted that figure 30c

is based on water-level measurements in well 208-912-16. This is an unpumped observation well located 200 feet from the nearest pumping well and, therefore, does not reflect the actual drawdown in the pumping wells. The water levels in the pumping wells are substantially lower than those in the observation well because drawdown increases toward a pumping well, and because some head is lost as water moves from the formation through the screen into the well. The pumping levels in the more efficient supply wells may be as much as 10 feet lower than the water level in the observation well.

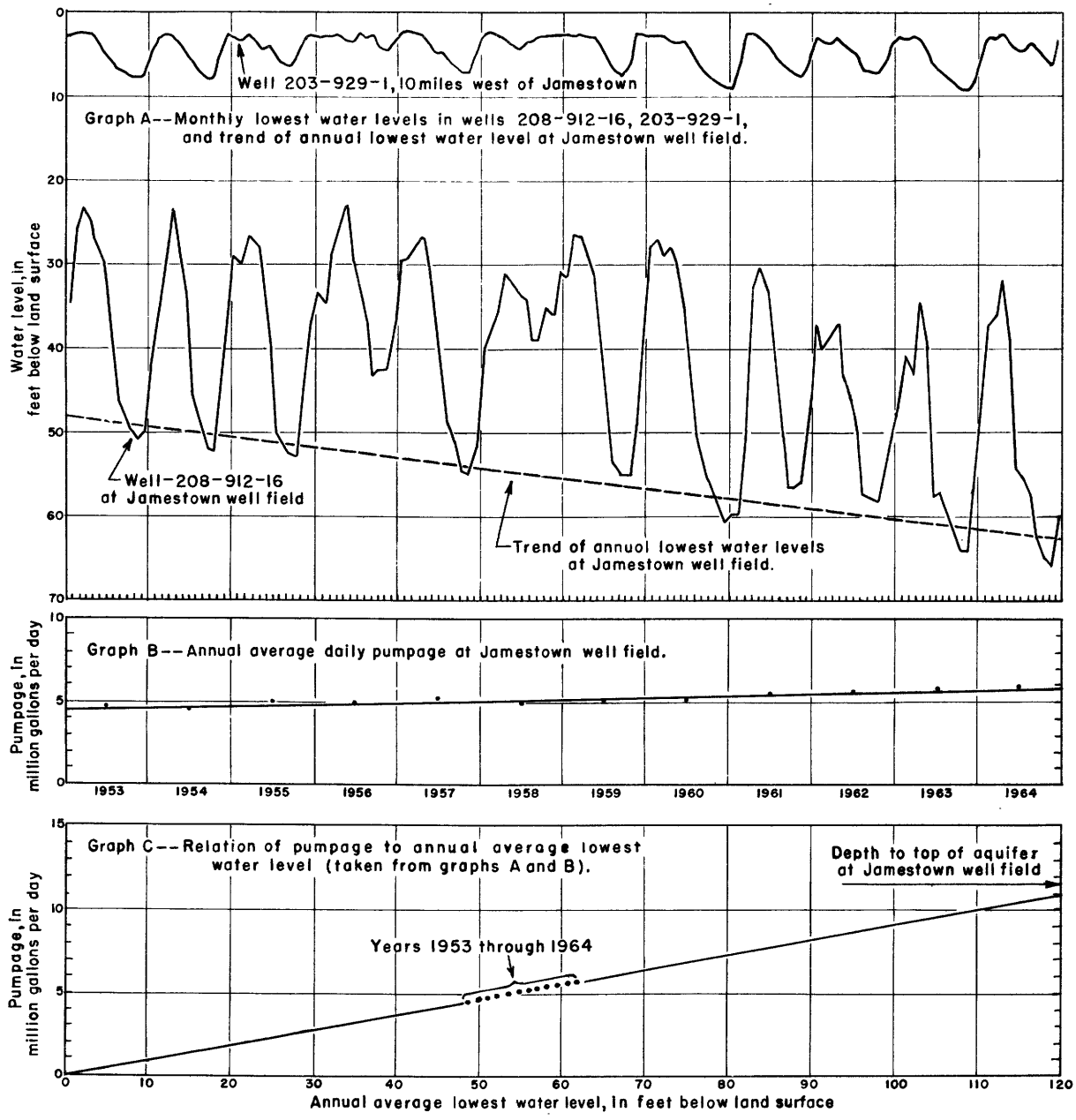

Well 203-929-1, 10 miles west of Jamestown
Graph A--Monthly lowest water levels in wells 208-912-16, 203-929-1, and trend of annual lowest water level at Jamestown well field.
Water level, in feet below land surface
Well 208-912-16 at Jamestown well field
Trend of annual lowest water levels at Jamestown well field.
Graph B--Annual average daily pumpage at Jamestown well field.
Pumpage, in million gallons per day
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
Graph C--Relation of pumpage to annual average lowest water level (taken from graphs A and B).
Depth to top of aquifer at Jamestown well field
Years 1953 through 1964
Annual average lowest water level, in feet below land surface

Figure 30.--Monthly lowest water levels in wells 203-929-1 and 208-912-16, average daily pumpage at the Jamestown well field, and the relation of water levels to pumpage.

The pumping levels of most of the supply wells, however, are about 20 feet lower than the water level in the observation well. In any event, the difference in water level between the observation well and the pumping wells represents a decrease in available drawdown and must, therefore, be considered in using the graph in figure 30c. Because the drawdowns in the pumping wells are from 10 to 20 feet below the line shown in figure 30c, the actual maximum perennial yield of the well field is probably not more than 10 mgd and may be somewhat less as is pointed out in the following paragraph.

Because of the funnel shape of the deltas, the amount of water derived from storage per unit decline in head, decreases as dewatering progresses. Thus, a unit change in head in the deltas in April when the water table is high, yields a much larger volume of water than does an equivalent change in head in October when the dewatering is well advanced. As pumping rates increase, a proportionally larger share of the water must, therefore, be derived from the more distant deltas. Recalling the discussion of figure 26, it can be seen that this will tend to reduce the maximum perennial yield. The amount of the reduction that might result is, of course, not known but would certainly not be as much as 2 mgd and might, in fact, be less than 1 mgd. However, so far as the following discussions are concerned the value of 10 mgd will be used.

Increasing the yield of the Jamestown aquifer

It is apparent that the water needs of the city of Jamestown will soon exceed the estimated maximum yield of the city's present well field. Long before this point is reached the city must either devise ways to increase the yield of its present well field, develop a new well field in a different part of the aquifer, or develop a new well field in some other aquifer. Each of these possibilities will be explored in the following paragraphs.

It is apparent from the preceding discussions that the water available to supply the deltas is substantially more than the estimated yield of the well field. The difficulty arises in the uneven distribution of the water. The yield of the well field could be increased if some of the water that now runs off during the winter and early spring in the streams crossing the deltas could be held until the summer. As pointed out by Mr. Merle W. Smedberg, Superintendent of the Jamestown Board of Public Utilities, this could be accomplished by building dams on the tributary streams above the deltas. It would seem feasible to increase the yield of the well field several million gallons per day by this method. Before a relatively accurate estimate can be made it will be necessary to obtain a continuous record of the flow of one or more of the tributary streams for a period of two or three years.

The studies made during this investigation indicate that the Jamestown aquifer extends up the valley at least as far as Towerville Corners. As discussed in the section on recharge in the upper Cassadaga Creek valley, it is possible that the aquifer extends up the valley beyond South Stockton. If the delta built by Mill Creek is hydraulically connected to the aquifer, as appears probable, it may be feasible to develop a well field in the vicinity of the Mill Creek delta capable of yielding several million gallons per day. Such a field would salvage water that is now discharging into Cassadaga Creek. It might cause some reduction in the yield of the present

field but the combined yield of both fields would be substantially greater than that of the present field. Before an accurate estimate can be made of the yield of a well field in the vicinity of Mill Creek, it will be necessary to drill test wells to determine the character, extent, and water-bearing characteristics of the aquifer in the area. The nature (or more correctly, the efficiency) of the hydraulic connection between the aquifer and the Mill Creek and Towerville Corners deltas should be an important part of any study in the area.

With respect to developing an additional source of water in another aquifer, the study leading to this report showed only one promising area. This area, which is located along Conewango Creek near Poland Center, was originally thought to be a part of the Jamestown aquifer. However, test wells constructed by the city of Jamestown while this report was in preparation indicated that the water-bearing deposits near Poland Center are either not hydraulically connected to the Jamestown aquifer or that any connection that does exist is very poor. For this reason, these deposits are discussed in the following section devoted to the Conewango Creek valley. The data available on these deposits at this time suggest that they may be capable of yielding a few million gallons per day. A much more accurate figure will obviously be available when the present testing program of the city is completed.

DELTAS AS AQUIFERS

In the preceding section on the Jamestown aquifer, considerable discussion was devoted to the deltas along the sides of the Cassadaga Creek valley. As was pointed out, these deltas serve as the principal sites of recharge to the aquifer. The present withdrawals from the Jamestown aquifer appear to be utilizing most of the water available in the deltas from Wilson Hollow to Hatch Creek at Gerry. As withdrawals from the aquifer are increased over the years, more and more of the storage in the deltas up the valley from Gerry will doubtless be used. However, because the deltas consist of relatively large masses of highly permeable material, they must be considered not only as sources of recharge to the Jamestown aquifer but as aquifers in themselves.

The deltas in the Cassadaga Creek valley are shown in plate 1. They consist of the roughly triangular-shaped areas of sand and gravel that extend out into the valley along each of the tributary streams, including the Chadakoin River. It may be observed in plate 1 that the deltas of Hatch Creek (at Gerry) and Mill Creek grade into sand deposits toward the center of the valley. The flood plain of the Chadakoin River and most of the outer part of the delta deposits are underlain by sand. The flood plain in the village of Falconer is bordered by sand and gravel deposits. Because the deposits comprising the delta of the Chadakoin River differ substantially from those of the other deltas, it will be discussed separately at the end of this section.

The deposits comprising the deltas consist of very coarse sand and coarse gravel adjacent to the valley wall which grades into sand toward the center of the valley. The sand layers and a few persistent gravel layers "interfinger" toward the center of the valley with the layers of silt and

clay that comprise the major part of the valley deposits. The gradation and the interfingering of the delta deposits are shown in figure 18, and the interfingering is shown in figure 22. The delta deposits extend from the land surface at least to the depth of the Jamestown aquifer. Therefore, their thickness ranges from 120 feet to possibly more than 170 feet. (See table 4.) These substantial thicknesses, however, could be misleading. As was pointed out in the discussion of the Jamestown aquifer, the delta deposits are roughly funnel shaped with the wide part of the funnel at land surface and the narrow part at depth.

The deltas are recharged both by direct precipitation and by water that infiltrates from the streams crossing them. Most of this recharge occurs during the fall, winter, and early spring. Water discharges from the deltas by outflow at land surface around the periphery of the deltas and by downward percolation into the Jamestown aquifer. Because of the highly permeable nature of the delta deposits, storage is rapidly depleted in the spring through the peripheral discharge zone. Thus, the water levels in wells penetrating these deposits show a rather rapid decline in the spring and a much more gentle decline thereafter. (See figure 21.)

The only water presently being developed directly from any of the deltas, for other than domestic needs, is at the Mill Creek delta. The village of Sinclairville has developed a well (215-916-3) in this delta which yields 150 gpm. The well is used as an auxiliary supply to supplement the yield of spring 217-913-1Sp, which is located in the uplands east of the village. Most of the domestic wells consist of small-diameter driven wells equipped with a screened drive point. The yield of some of these wells exceeds 30 gpm. It should be possible in many of the deltas to construct screened supply wells capable of yielding a few hundred gallons per minute. The number of such wells that any delta can supply on a perennial basis depends on the amount of water in storage and the rate of recharge during the summer months. As most recharge during the summer is probably derived from stream infiltration, the yield of any delta is largely dependent on storage and the inflow from the stream crossing the delta. (Both these factors are discussed in considerable detail in the preceding discussion of the Jamestown aquifer.)

The future development of large water supplies from the deltas must be considered from the standpoint of the Jamestown aquifer. The aquifer drains water essentially from the bottom of the deltas. Therefore, the most effective water supply use of the deltas may be as sources of recharge (reservoirs) for the Jamestown aquifer. Certainly any large-scale withdrawals from the deltas between Wilson Hollow and Hatch Creek would have a highly detrimental effect on the yield of the present Jamestown well field.

The Chadakoin delta, comprising the deposits laid down by the Chadakoin River where it enters the lower Cassadaga Creek valley, serves as an important source of industrial water supplies in and near the village of Falconer. The industrial pumpage in the area is estimated to be about 1.2 mgd. The surficial deposits of this delta appear to be composed principally of sand (pl. 1). However, deposits of sand and gravel are also present as shown on section A-A' in figure 15. It should be noted that this section cuts diagonally across the delta and is based entirely on generalized drillers' logs. It, therefore, provides only a rough idea of the

nature and extent of the delta deposits. For example, the available data are not conclusive with respect to the hydraulic connection between the delta deposits and the Jamestown aquifer. The two are apparently not connected along section A-A' but may be connected at other places. In fact, small daily fluctuations observed on water-level recorder charts from the Jamestown well field are believed to be caused by pumping from industrial wells at Falconer which penetrate the delta deposits.

Several industrial supply wells along the Chadakoin River in the village of Falconer draw water from a layer of sand and gravel in the delta deposits. The layer is only about 5 feet thick and is overlain by about 30 feet of silt and clay. Individual wells drawing from this layer yield as much as 450 gpm with specific capacities as high as 70 gpm per foot. (See records for wells 206-912-1, -2, -3, -4, and 206-911-1, -5, -6, and 7.) Although there is no direct evidence of stream infiltration, it appears certain that such infiltration does occur and supplies a part of the industrial pumpage. It is probable that larger quantities of water can be developed from the Chadakoin delta deposits in the Falconer area, particularly where permeable layers in the deposits are in contact with the river.

DEPOSITS IN THE UPPER CASSADAGA CREEK VALLEY

The two upper branches of the Cassadaga Creek valley contain extensive surficial deposits of sand and gravel (pl. 1). These deposits surround the Cassadaga Lakes and border the Bear Lake Outlet. The deposits of sand and gravel are generally restricted to the upper ends of the valley. To the south the deposits grade into sands that fringe the eastern sides of the valley. The most extensive of these sand deposits underlies the area near the confluence of Cassadaga Creek and Bear Lake Outlet, east and south of the hamlet of Pleasant Valley. The extreme upper ends of the valley, northwest of Bear Lake and north of the Cassadaga Lakes, are underlain by mixed deposits of till and sand and gravel.

The character of the sand and gravel deposits in the western branch of the valley, in the vicinity of Bear Lake, are shown along sections A-A', B-B', and C-C' in figure 13. As shown on the sections, the deposits consist of layers of sand and gravel interbedded with layers of sand. They are underlain by silt and clay or by till. The deposits of sand and gravel and of sand are about 125 feet thick immediately south of Bear Lake and thin down the valley to about 30 feet in the vicinity of well 217-921-4. The deposits south of Lower Cassadaga Lake are shown on section D-D' in figure 13. The deposits along this section consist of a surficial layer of about 20 feet of sand and gravel underlain by silt and clay.

The sand and gravel deposits are the most important source of ground water in the upper Cassadaga Creek valley (pl. 3). They are recharged by precipitation and, where heavily pumped wells are close to streams, by stream infiltration. Recharge from precipitation probably averages about 1 mgd per square mile. Most of the streams crossing the deposits are small and the amount of water available for infiltration is not large, especially during the summer.

The yield of wells in these deposits is governed by the transmissibility. In order to obtain information on transmissibility, a pumping test was conducted at the well field of the village of Cassadaga. The aquifer at this location consists of a deposit of sand and gravel which is about 15 feet thick and is overlain by 4 feet of silt and clay.

During the test, well 220-919-2 was pumped at a rate of 170 gpm for 4 hours and 33 minutes. Drawdowns were measured in wells 220-919-4 and -5 which are located 114 and 50 feet, respectively, from the pumping well. Figure 31 shows a plot of the drawdowns in these two wells with respect to time, on logarithmic paper, and other basic data concerning the test. All drawdowns have been corrected for a slight rise in static water level during the test.

The data were analysed according to the Theis non-equilibrium method (Wenzel, 1942, p. 87-91). This method allows the drawdown about the pumping well to be analysed in relation to the quantity and duration of discharge. The formula used for determining the transmissibility and storage coefficient is as follows:

$$s = \frac{114.6Q}{T} \int_u^{\infty} \frac{e^{-u}}{u}\, du = \frac{114.6Q}{T} W(u),$$

where: $u = \frac{1.87\, r^2 S}{Tt}$,

T = the coefficient of transmissibility of the aquifer in gpd per foot,

S = the coefficient of storage of the aquifer, a dimensionless fraction,

Q = discharge of well in gpm,

s = drawdown of water level, in feet, at any point,

r = distance, in feet, from pumping well to the point where the drawdown is measured,

t = time of pumping, in days, required to produce drawdown "s,"

$W(u)$ = "well function of u," constant discharge situation (replaces exponential integral),

e = natural-logarithm base, numerically equal to approximately 2.72.

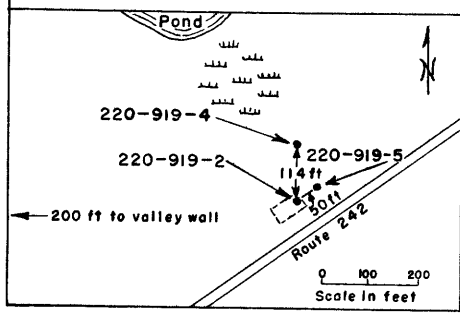
The formula is based on the following assumptions: (1) the aquifer is homogeneous and isotropic (has the same permeability in all directions); (2) the aquifer is of infinite areal extent; and (3) the discharging or

recharging well penetrates and receives water from the full saturated thickness of the aquifer. Although it is not possible to meet all of these conditions with any one naturally occurring aquifer, and this test did not, the results obtained with the formula are reasonably accurate and quite useful.

Pumping test of December 6, 1962
at Cassadaga, N.Y.

Well 220-919-2 was pumped at a rate of 170 gpm while water levels were measured in wells -4 and -5. Well 220-919-2 is screened from 10 to 19 feet, while wells -4 and -5 both end with open casing. The measuring point (m. p.) on well 220-919-4 (114 feet from pumping well) is at land surface. The measuring point for well -5 (50 feet from pumping well) is 2.5 feet above land surface.

The aquifer consists of sand and gravel from 4 to 19 feet. Selected drawdown data listed at the right have been corrected for changes in static water level.



Well 220-919-5			Well 220-919-4		
Time (Minutes)	Depth to water below m. p. (feet)	Corrected drawdown (feet)	Time (Minutes)	Depth to water below m. p. (feet)	Corrected drawdown (feet)
0	6.19	0	0	2.50	0
1	6.50	.31	2	2.53	.03
2	6.64	.45	3	2.58	.08
3	6.78	.59	4	2.62	.12
4	6.80	.61	5	2.65	.15
5	6.86	.67	6	2.69	.19
6	6.90	.71	7	2.73	.23
7	6.89	.70	8	2.76	.26
8	6.98	.79	9	2.79	.29
9	7.01	.82	10	2.82	.32
10	7.03	.84	12	2.87	.37
12	7.09	.90	14	2.93	.43
14	7.13	.94	16	2.96	.46
16	7.15	.96	18	3.01	.51
18	7.19	1.00	20	3.03	.53
20	7.22	1.03	24	3.10	.60
24	7.27	1.08	28	3.14	.64
28	7.31	1.12	32	3.18	.68
32	7.33	1.14	36	3.20	.70
36	7.37	1.19	40	3.23	.73
40	7.39	1.21	50	3.28	.78
50	7.44	1.26	60	3.32	.82
60	7.48	1.30	70	3.35	.85
70	7.52	1.35	80	3.37	.87
90	7.56	1.39	90	3.39	.89
110	7.58	1.42	110	3.42	.92
130	7.59	1.43	130	3.43	.93
160	7.61	1.46	160	3.45	.95
200	7.61	1.47	200	3.46	.96
240	7.61	1.48	240	3.47	.97
273	7.62	1.50	260	3.48	.98

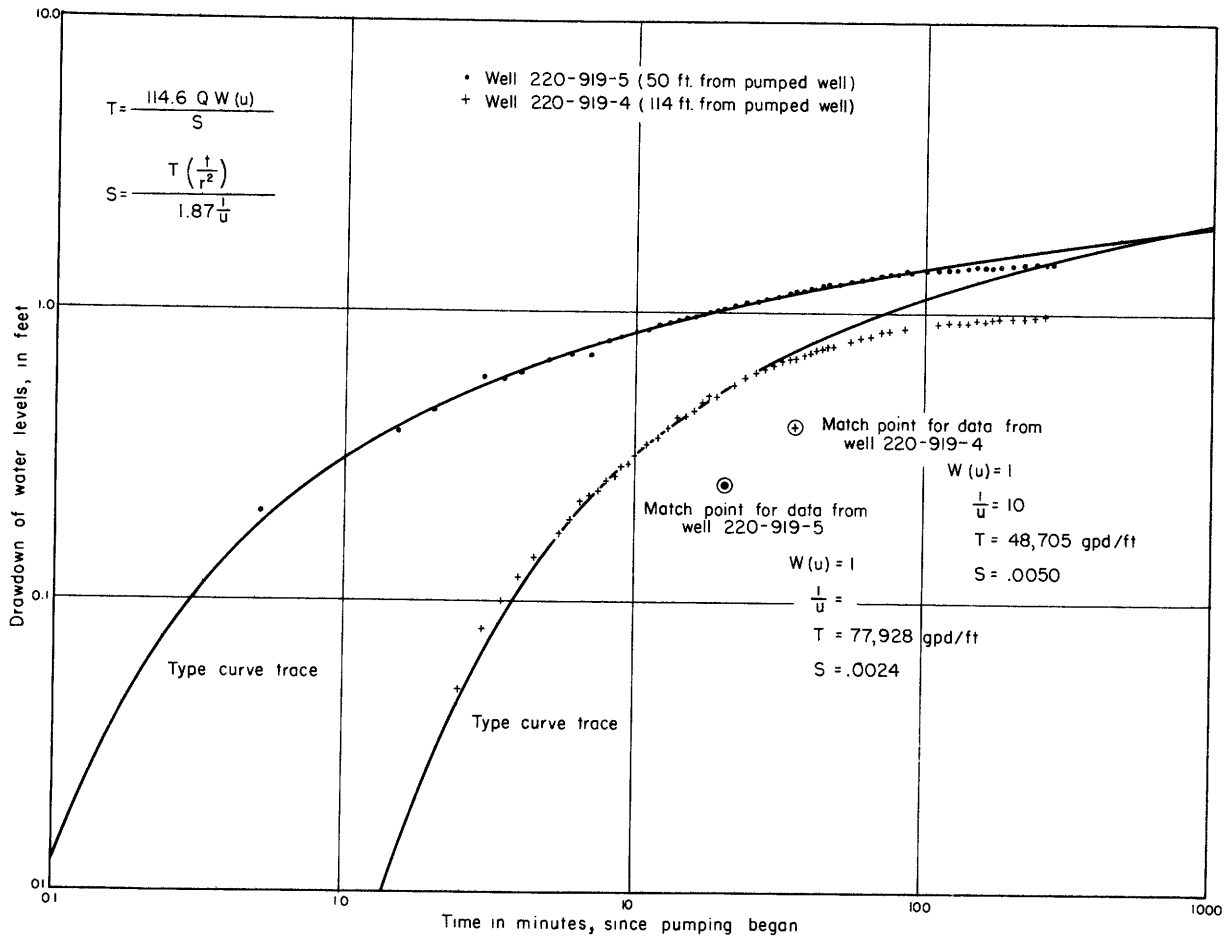


Figure 31.--Time-drawdown curves and basic data from a pumping test at the Cassadaga well field.

In order to determine the T and S values of the aquifer, the drawdowns in the observation wells are plotted against the time, in minutes, since the pumping started. The curve described by these points is a segment of the "type curve" produced by plotting the exponential integral W(u) against values of 1/u. The segment of the plotted data curve is superposed on the type curve and a "match point" for the values of W(u), 1/u, s, and t is selected. The values obtained are inserted in the formulas given above and values for T and S are determined. An excellent discussion of the "type curve" method of analysis may be found in recent papers by Ferris and others (1962, p. 92-98) and Bentall (1963, p. 19-23).

The match of the type curve with segments of the plots of the drawdown data yields values of about 78,000 and 49,000 gpd per foot for the transmissibility of the deposit at Cassadaga. The storage coefficients were computed to be 0.0024 and 0.0050.

It will be noted in figure 31 that the plot of the drawdown data for both wells diverges below the type curve during the latter part of the test, and by the end of the test, water levels in the deposit had nearly stabilized. In other words, the drawdowns resulting from the pumping were less than would have been predicted with the Theis equation. The divergence of the drawdowns below the type curves may be due to any of three possible causes: (1) vertical leakage through the silt and clay layer overlying the aquifer, (2) recharge from a nearby surface-water body, or (3) a change from artesian to water-table conditions in the aquifer.

An examination of the drawdown plots seemed to indicate that leakage through the confining bed was the cause of the divergence. In fact, the drawdown plots match almost perfectly with the type curve developed for leaky artesian aquifers by Hantush and Jacob (1955). However, the leaky artesian analysis requires that a constant supply of water be available above the leaking confining bed. The geology at the pumping-test site indicates that this is not the case because the confining bed of silt and clay is exposed at land surface around the well field. The departure also could not be caused by recharge from precipitation reaching the aquifer because there was no appreciable rain during the 12 days preceding the test.

The second explanation for the deviation from the type curve seemed possible because there are several swamps and ponds within a short distance of the well field. The closest surface-water body is the pond north of the field (fig. 31). If the pond had been contributing water to the aquifer, it should have reduced the drawdowns most noticeably in well 220-919-4, which is between the pond and the pumping well. This reduction in drawdown, at the observation well, would cause the computed transmissibility at that well to be higher than that computed at well 220-919-5. However, just the opposite is true, and surface-water recharge must be ruled out as the major factor influencing the decline in the rate of drawdown.

The third possible cause is that the water in the aquifer was under artesian conditions at the start of the test but started through a transition phase to water-table conditions at the time when the divergence began. This is not an unusual occurrence. A pumping test in eastern New York during which the aquifer went through a transition from artesian to water-table conditions is described by Heath and Tannenbaum (1963, p. 112-114).

The transition from artesian to water-table conditions creates a decline in the rate of drawdown because, under water-table conditions, a large amount of water is derived from dewatering of the aquifer. The amount of water derived from storage under artesian conditions is insignificant and a change to water-table conditions would appear as the addition of water to the system. An analysis of water levels in the aquifer, before and during the test, indicates that as the test began the water level in the aquifer was slightly above the bottom of the confining bed. Even though the amount of drawdown was not large, it appears that it was large enough, at least in the vicinity of the pumping well, to decline below the bottom of the confining bed and to cause dewatering in a portion of the aquifer.

In summary, the test showed that the aquifer in the Cassadaga area, although thin, has a fairly high transmissibility. Therefore, it may be developed to yield greater amounts of water than are presently being pumped.

No pumping test was conducted in the deposit of sand and gravel along Bear Lake Outlet. However, well 219-921-1 at Stockton has a reported specific capacity of 100 gpm per foot. The specific capacity of a well is the yield in gpm per foot of drawdown. Because the yield of a well is proportional to drawdown, the specific capacity roughly indicates the transmissibility of an aquifer. This would indicate a transmissibility of about 150,000 gpd per foot for well 219-921-1. The reported specific capacity may be somewhat high, but it is evident that the deposit has a high transmissibility.

The large deposits of sand (pl. 1) which underlie the area to the north and east of the junction of Bear Lake Outlet and Cassadaga Creek are somewhat similar hydrologically to the deposits previously discussed. These deposits are relatively thin and in hydraulic contact with nearby streams. However, they are composed of fine to medium sand and, thus, probably have a moderately low permeability. They do not yield water readily to wells, and many of the wells developed in these deposits are large-diameter dug wells. It is possible to utilize these deposits to obtain yields adequate for ordinary domestic or farm uses. Because of the low permeability and thinness of these deposits, moderate to large yields would probably require the construction of horizontal "collecting" galleries.

Water is drawn from the permeable deposits in the upper part of the Cassadaga Creek valley from the two supply wells at the village of Cassadaga and from numerous farm and domestic wells. The pumpage of the village of Cassadaga amounts to about 140,000 gpd. It is probable that several additional sites capable of yielding 100,000 to 200,000 gpd could be developed in the area.

CHAUTAUQUA LAKE VALLEY

The Chautauqua Lake valley is shown on the southwestern portion of plate 1 and the western portion of plate 2. For purposes of this discussion, the valley is considered to include all of the low-lying land surrounding Chautauqua Lake, the upper Chadakoin River, and the floor of the tributary valley extending to the southwest from Ashville. It excludes the till and bedrock uplands adjacent to these areas which were discussed in an earlier section of this report.

As in the Cassadaga Creek valley, the valley of Chautauqua Lake is filled with great thicknesses of unconsolidated material. Very few wells penetrate the deeper parts of these deposits because of the large portion of the valley occupied by the lake itself. However, Muller (1963, p. 35) reports that a well drilled about 2 miles northwest of Hartfield, near the north end of the lake, penetrated over 400 feet of unconsolidated material without reaching bedrock. Well 209-923-6, at Bemus Point, is reported to be 400 feet deep and did not reach bedrock (table 6). Information from wells 206-915-1 and -2, at the eastern end of the valley, indicates that the bedrock floor is more than 200 feet below land surface in that area. Data from wells in the valley extending southwest from Ashville show that bedrock is 200 to 300 feet below the land surface in that area. Well 202-925-1, near Watts Flats, reached bedrock at 293 feet. Depths to bedrock and logs of wells are given in table 6 and figure 43, respectively.

Plates 1 and 2 show the surficial deposits in the Chautauqua Lake valley. Most of the large areas of surficial sand and gravel around Chautauqua Lake were deposited by glacial melt water. This deposition apparently took place around the fringe of an ice tongue which extended from the north to about the area of Bemus Point. As the ice completely melted, these deposits were left around the margin of the valley. The only extensive coarse deposits on the floor of the valley occurred at Bemus Point and Long Point where material was deposited as a moraine at the end of the ice tongue. Because of their manner of formation, the sand and gravel deposits are generally thickest near the valley walls and thin toward the center of the valley. Most of the deposits are above the present level of Chautauqua Lake. However, in the area of Bemus Point and Long Point, sand and gravel deposits extend below lake level.

In addition to the sand and gravel deposited in the valley by glacial melt water, several of the sand and gravel deposits that border Chautauqua Lake were laid down as deltas by tributary streams entering the lake. Two easily identifiable deltas are the sand and gravel deposit at Greenhurst; and the large deposit of sand and gravel and of sand south of Chautauqua. Both of these deltas may be recognized in plate 2 by their roughly triangular shape and the extension of the deposits into the lake. However, delta deposits which are not as apparent at first glance, occur wherever tributary streams enter the lake. These other stream deposits, consisting mainly of sand and gravel, occur at Mayville, Dewittville, and between Bemus Point and Phillips Mills. Most of the delta deposits around Chautauqua Lake are smaller and, therefore, less obvious than those in the Cassadaga Creek valley. However, they have many of the same features. For example, the coarsest and thickest deposits occur near the valley walls in the upstream portion, and the delta deposits generally become thinner and interfinger with silt and clay toward the lake.

Large areas of mixed deposits which consist of a complex mixture of till, sand and gravel, and silt and clay are shown in plates 1 and 2 north of Mayville, at Jamestown, and south of Chautauqua. These deposits were formed at the end of ice tongues as terminal moraines.

Although large areas of coarse-grained deposits are shown in plate 2, it is apparent from the available well logs that most of the unconsolidated material in the Chautauqua Lake valley is fine grained. The subsurface

relationship of the deposits is complex, as is the case in the other valleys. Figure 32 shows geologic sections across the valley of Chautauqua Lake near Bemus Point and in the Watts Flats areas. The section at Bemus Point shows the deposits of sand and gravel along both sides of the valley. Toward the center of the valley these deposits become fine grained consisting predominantly of silt and clay with a few thin beds of sand or gravel at various depths. The deeper portion of the valley consists of great thicknesses of silt and clay. This sequence of deposits is typical along the lake. Section B-B' in figure 15 shows a cross section of the deposits at the eastern end of the Chautauqua Lake valley. This section shows the large amount of silt and clay present at the south end of the lake and the complex mixed materials in the moraine at Jamestown.

In the valley extending southwest from Ashville, there are extensive deposits of sand and of mixed material (pl. 2). The deposits in this area were formed by deposition as a terminal moraine of an ice lobe and as outwash in front of the terminal moraine. One interesting fact is that the moraine and the outwash in the area are so exceptionally fine grained. As shown on section B-B' of figure 32, more than 200 feet of fine sand occurs along the north side of the valley at Watts Flats. It is probable that the source of most of these deposits is previous lake deposits which were eroded by the ice from the Chautauqua Lake valley and transported and redeposited by the ice sheet. Some coarser material is incorporated in the deposits to the northwest of Watts Flats, but coarse materials seem to be almost entirely lacking to the southwest.

The surficial deposits of sand and gravel shown in plates 1 and 2 roughly delineate the principal water-bearing deposits in the Chautauqua Lake valley. The yields, to individual wells, of the deposits in the valley are shown in plates 3 and 4. Most of the sand or gravel deposits around the lake are very permeable and capable of transmitting large quantities of water. However, because most of them lie above the level of perennial streams or the lake, they do not have thick saturated zones. Although they are readily recharged by precipitation, they drain relatively rapidly after periods of recharge. Therefore, during the late summer and early fall, relatively little water remains in storage in the deposits. Where these deposits occur below the level of Chautauqua Lake or a perennial stream, recharge may be induced by pumping from nearby wells.

A pumping test was conducted at the Mayville well field in order to determine some of the hydraulic characteristics of the delta deposits that serve as a source of supply for the village. The aquifer at the well field is composed of sand and gravel about 5 feet thick which is overlain by about 20 feet of mixed fine sand and silt and clay. This fine-grained material appears to thin and disappear to the north and west of the well field. During the test, well 214-930-2 was pumped at a rate of 300 gpm for 7 hours and 30 minutes. The drawdowns of water level were measured in wells 214-930-3 and -4, 75 feet and 140 feet from the pumping well, respectively. Figure 33 shows a plot on logarithmic paper of the recovery of water levels, corrected for residual drawdown, in the observation wells along with other basic data concerning the test. The leaky type curves were used in matching with the plotted data. The leaky type curves (Hantush and Jacob, 1955) are a modification of the Theis type curve which was described earlier.

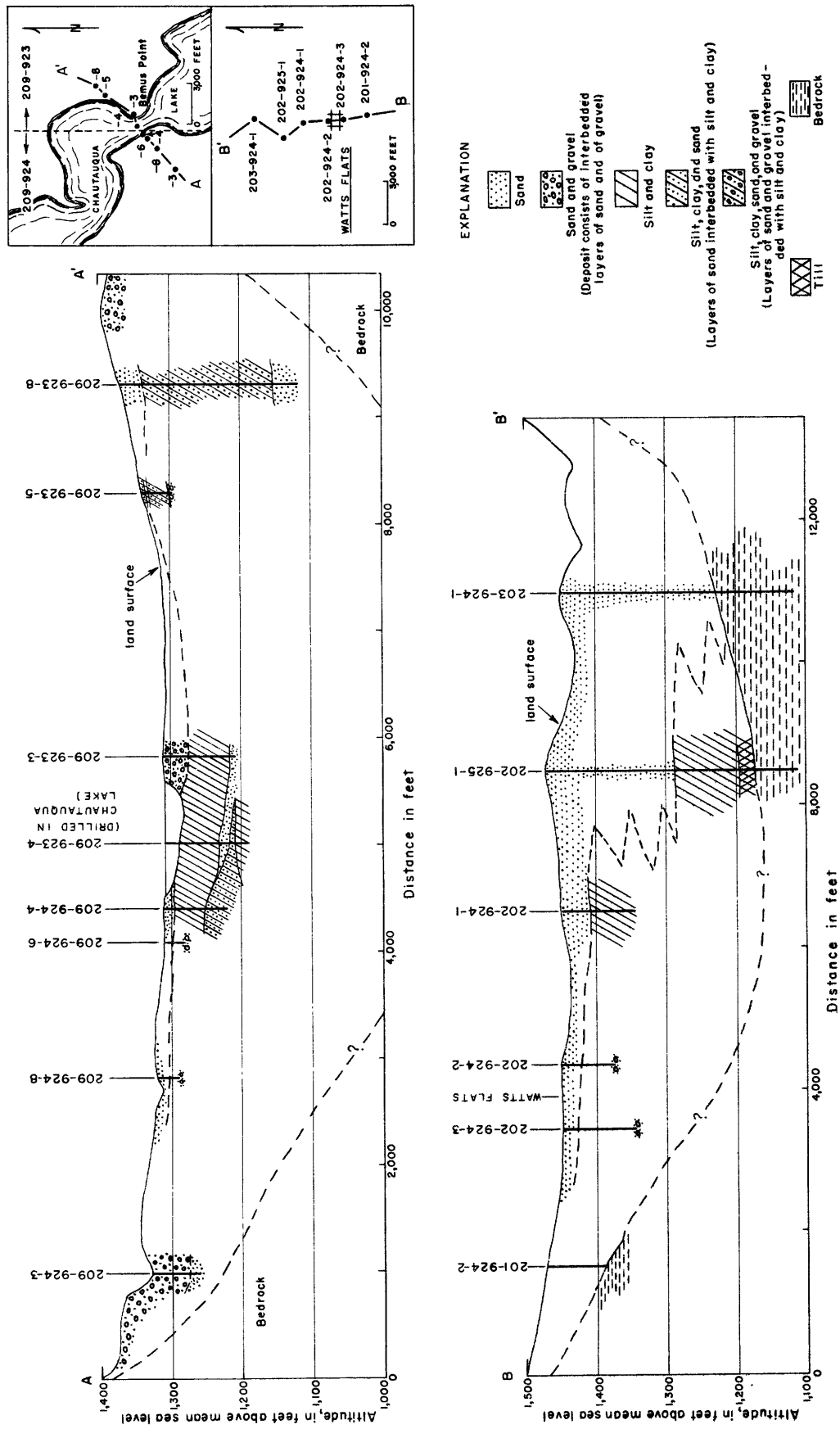
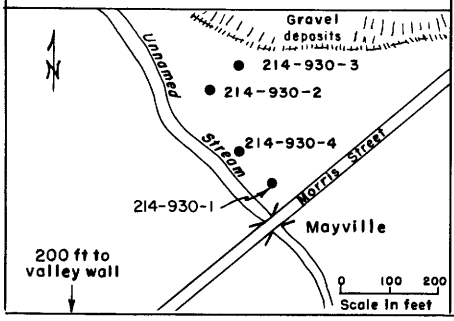


Figure 32.--Geologic sections across the Chautauqua Lake valley near Bemus Point and across the Watts Flats area.

Pumping test of November 29, 1962 at Mayville, N.Y.

Well 214-930-2 was pumped at an average rate of 300 gpm while water levels (before and after pumping) were measured in wells 214-930-3 and -4, located 75 feet and 140 feet from pumped well, respectively.

The aquifer consists of sand and gravel located between depths of 21 to 26 feet below land surface. Measuring point (m. p.) on well 214-930-3 is at land surface, and on well -4 it is at 2.0 feet above land surface. Land surface at two wells is not at same altitude. Table at right lists selected recovery measurements, corrected for residual drawdown.



Well 214-930-3			Well 214-930-4		
Time (Minutes)	Depth to water below m. p. (feet)	Corrected recovery (feet)	Time (Minutes)	Depth to water below m. p. (feet)	Corrected recovery (feet)
0	9.46	0	0	10.34	0
1	9.41	.05	1	10.30	.04
2	9.28	.18	2	10.20	.14
3	9.10	.36	3	10.06	.28
4	8.90	.57	4	9.91	.44
5	8.72	.75	5	9.77	.58
6	8.51	.96	6	9.63	.72
7	8.32	1.15	7	9.48	.87
8	8.14	1.34	8	9.33	1.03
9	7.96	1.52	9	9.19	1.16
10	7.79	1.69	10	9.05	1.30
12	7.45	2.04	12	8.83	1.54
14	7.17	2.32	14	8.58	1.79
16	6.91	2.59	16	8.33	2.05
18	6.70	2.80	18	8.17	2.21
20	6.48	3.03	20	7.97	2.40
24	6.14	3.38	24	7.68	2.69
28	5.87	3.66	28	7.42	2.96
32	5.65	3.89	32	7.21	3.18
36	5.46	4.09	36	7.03	3.36
40	5.29	4.27	40	6.86	3.54
50	4.95	4.63	50	6.54	3.87
60	4.68	4.92	60	6.29	4.13
70	4.47	5.15	70	6.05	4.39
80	4.26	5.37	80	5.84	4.61
102	3.89	5.77	100	5.53	4.93
120	3.68	5.99	120	5.29	5.18
140	3.55	6.15	140	5.12	5.37
170	3.43	6.28	170	4.88	5.62
190	3.24	6.48	190	4.76	5.74
230	3.07	6.66	240	4.49	5.93
270	2.89	6.86	280	4.31	6.12
320	2.71	7.06	320	4.19	6.25

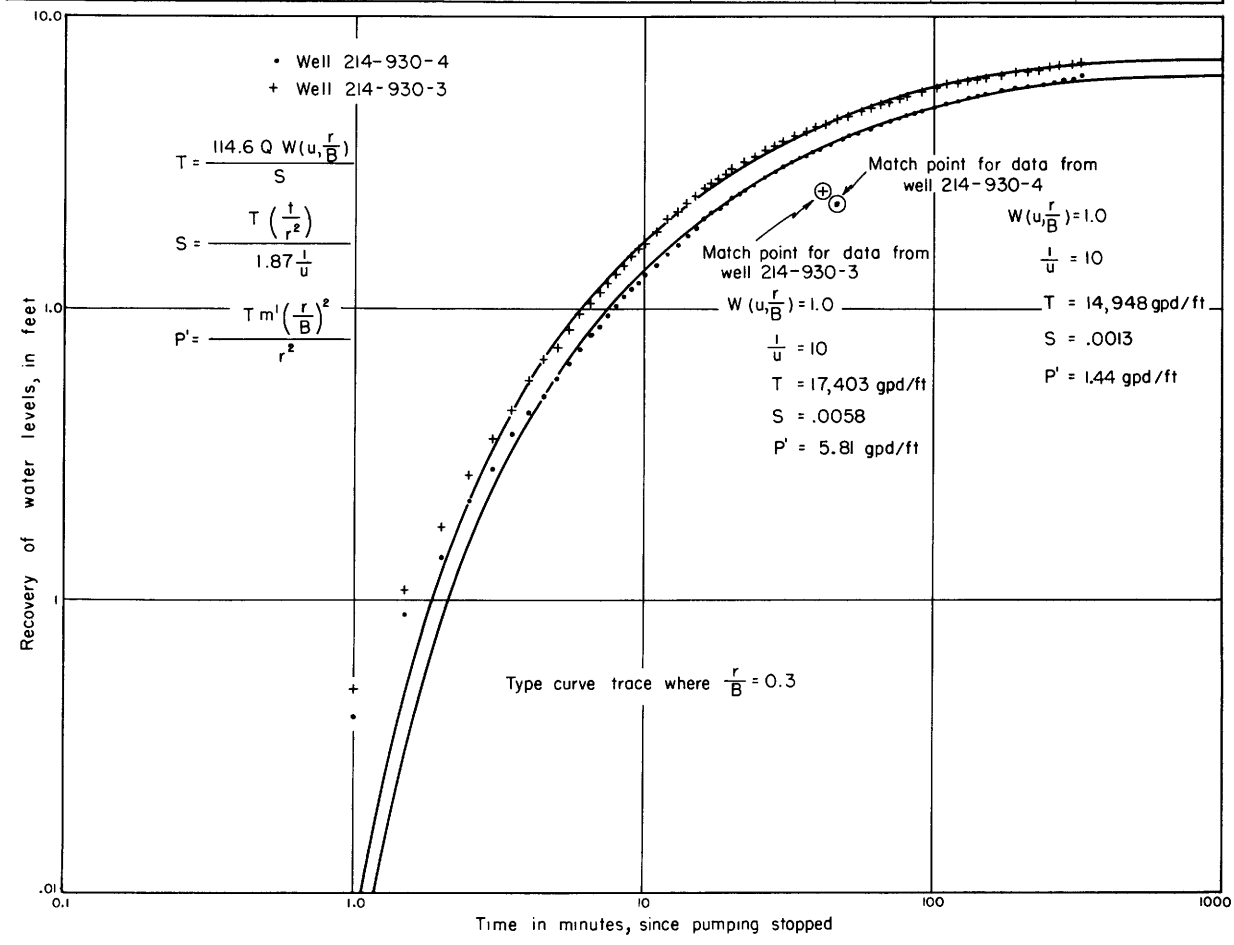


Figure 33.--Time-recovery curves and basic data from a pumping test at the Mayville well field.

The assumptions in using the leaky artesian aquifer type curves are similar to those used in applying the Theis non-equilibrium method, except that the confining bed is assumed to be leaking water to the aquifer. The leakage is proportional to the drawdown and it decreases the total amount of drawdown expected because water is being added to the aquifer to supply a portion of the pumpage. In order for the leaky artesian analysis to apply, an essentially constant source of water must be available to supply the leakage across the confining bed. The geology at the Mayville test site, especially with the small stream crossing the confining bed, makes this condition seem probable. A discussion of the development of the leaky type curves and their application may be found in a paper by Walton (1962, p. 4-6).

As shown in figure 33 the transmissibility of the aquifer was calculated to range from about 15,000 to 17,000 gpd per foot. The storage coefficients of 0.0013 and 0.0058 indicate that the aquifer is under artesian conditions. The permeability of the confining bed was computed to be 1.4 and 5.8 gpd per square foot for the two wells.

Well 214-930-2 is one of two supply wells owned by the village of Mayville. The other supply well, 214-930-1, is located about 200 feet south of well -2. The pumpage of the village from these two wells averages about 250,000 gpd.

The village of Lakewood now obtains water from well 206-918-1 which yields about 350 gpm. Prior to the construction of this well in 1961, the village obtained its supply from two wells located about half a mile northeast of Ashville. These wells were abandoned except for supplemental supply in the summer because the water contained hydrogen sulfide gas. The water-bearing material at both well 206-918-1 and at the abandoned field consists of sand and gravel overlain by silt and clay. The specific capacities of test wells 206-921-3 and -4 near Ashville, at the former site of the Lakewood well field, ranged from about 20 to 40 gpm per foot, indicating a transmissibility for the sand and gravel there of about 30,000 to 60,000 gpd per foot. The deposit probably receives recharge along the margins of the Goose Creek valley. The hydrogen sulfide gas may indicate that water moves into the sand and gravel from the underlying bedrock. Well 206-918-1 is finished with a 10-foot screen in sand and gravel between depths of 62 and 72 feet. The geology of the area suggests that recharge occurs along the valley wall south of the well field. However, because the pumping water level is 40 to 50 feet below the level of Chautauqua Lake, it is probable that some water is derived from the lake. Specific capacity of the well is about 11 gpm per foot which suggests a transmissibility of about 15,000 gpm per foot. The pumpage of the village of Lakewood averages about 400,000 gpd.

The coarse-grained deposits along the upper Chadakoin River valley appear to be very similar to those surrounding Chautauqua Lake in that they tend to lie along the valley walls with extensions underlying the lake deposits.

The deposits from which wells 206-915-4 and -5 are obtaining water appear to be confined portions of the large sand and gravel deposit immediately to the south, which at the site of the wells is interbedded with silt and clay. The deposits appear to be quite small in areal extent because

test wells 206-915-1 and -2 reportedly did not penetrate any such deposits further out toward the center of the valley. The only source of recharge appears to be from the coarse-grained deposit to the south. Although well yields of 200 to 300 gpm are reported from these deposits, drawdowns are fairly large and specific capacities of wells in the area are only about 15 gpm per foot, indicating transmissibilities of about 20,000 gpd per foot.

There are no large water supplies presently developed in the Chautauqua Lake valley. There are several small public water systems around the lake. The daily use of these ranges from the 5,000 gpd used by the Woodlawn Water District to the 400,000 gpd used at Lakewood. It is probable that small to moderate supplies can be developed at several other places around the lake. However, because most of the productive deposits do not seem to be freely connected to Chautauqua Lake, the development of large ground-water supplies in the valley is probably not feasible.

CONEWANGO CREEK VALLEY

The Conewango Creek valley as used here includes all the valley area drained by Conewango Creek from Cherry Creek to the Pennsylvania State line except the areas drained by Cassadaga Creek and Chautauqua Lake. The Conewango Creek valley extends in a north-south direction along the eastern side of the project area (pl. 2). The central part of the valley is shown in plate 1.

It may be observed in plates 1 and 2 that the Conewango Creek valley consists of three distinct segments. South of Cherry Creek for a distance of 9 miles, the floor of the valley is 1 to 2 miles in width and is exceptionally flat. In the vicinity of Waterboro and Kennedy the valley floor is only a few hundred feet wide. South of Kennedy the valley again widens out and takes on much of the same aspect as the northern segment.

The unconsolidated deposits in the Conewango Creek valley are thicker than those in any other part of the project area. In fact, very few wells on the valley floor enter bedrock because of the great thickness of the unconsolidated deposits. Approximately 5 miles north of Cherry Creek, near the center of the Conewango Creek valley but outside the project area, the depth of unconsolidated material is reported to be greater than 1,000 feet (Muller, 1963, p. 49). Well 215-902-2, 3 miles southeast of Cherry Creek, was drilled to a depth of 583 feet without reaching bedrock. Also, well 212-901-7, 2 miles southeast of Clear Creek, was drilled to a depth of 421 feet without reaching rock. The depth to bedrock is less in the Waterboro-Kennedy area. A test well drilled by the Geological Survey at Kennedy (well 209-906-6) penetrated bedrock at a depth of 170 feet. The depth to bedrock increases again in the southern part of the valley. Well 205-907-3, near Frewsburg, reached bedrock at 340 feet. Well 203-911-6 was drilled to 225 feet without reaching bedrock.

The deposits in the main Conewango Creek valley are predominantly glacial-lake deposits of silt and clay. Deltas composed largely of sand and gravel have been built along the sides of the valley by tributary streams. Deposits of sand and gravel, and mixed deposits of sand and

gravel and till border the sides of the valley in places. The tributary valleys, such as those of Clear Creek and Stillwater Creek, contain extensive deposits of sand and gravel overlying till.

Figure 34 shows the lithology and the relationships of the deposits at three locations in the Conewango Creek valley. These sections are relatively incomplete because only a few well logs are available for the valley. However, it may be noted that the material filling the valley in these areas is predominantly fine grained with only thin layers of sand or gravel at various depths. The only extensive coarse-grained deposits are found along the valley walls.

Two sections across the valley, one at Kennedy and one at Poland Center, are shown in figure 35. The section at Kennedy shows a good example of the nature of the high level sand and gravel deposits which underlie terraces in that area. The section at Poland Center illustrates the complexity of coarse-grained deposits which are overlain by and interbedded with silt and clay in the valley bottom.

For the purposes of the following discussion, the water-bearing deposits occurring in the valley have been grouped into (1) the upper Conewango Creek valley; (2) the middle Conewango Creek valley; (3) the Poland Center aquifer; and (4) the lower Conewango Creek valley. The availability of ground water to wells in the Conewango Creek valley is shown in plates 3 and 4.

UPPER CONEWANGO CREEK VALLEY

As noted previously, the upper Conewango Creek valley is underlain by several hundred feet of unconsolidated sediments. Because few wells penetrate the deposits to any substantial depth, relatively little is known about the character of the deeper deposits. However, from the few available well logs (fig. 43), it is apparent that most of the unconsolidated deposits in the valley are silt and clay. Deposits of sand and gravel underlie the valleys of tributary streams and occur as deltas where the streams enter the Conewango Creek valley from the adjoining uplands. Some lower layers of sand and gravel deposited by the larger creeks, including Cherry Creek, Mill Creek, and Clear Creek, appear to extend nearly across the valley.

The water-bearing deposits in the Conewango Creek valley are, thus, similar in occurrence to those in the Cassadaga Creek valley. The major differences between the two valleys appear to be (1) that the Conewango Creek valley apparently does not contain an extensive and continuous aquifer equivalent to the Jamestown aquifer, and (2) that the principal deltas in the Conewango Creek valley may be somewhat larger and more extensive than those in the Cassadaga Creek valley because they were formed by relatively large streams. Actually, the wells in the Conewango Creek valley are too widely scattered to determine whether a relatively continuous layer of sand and gravel, equivalent to the Jamestown aquifer, is present. The thin sand and gravel layers penetrated by wells in the central part of the valley can be interpreted either as one continuous layer or as extensions of deltaic layers out into the valley. The available data tend to support the latter explanation, but this may be proven wrong when additional data become available.

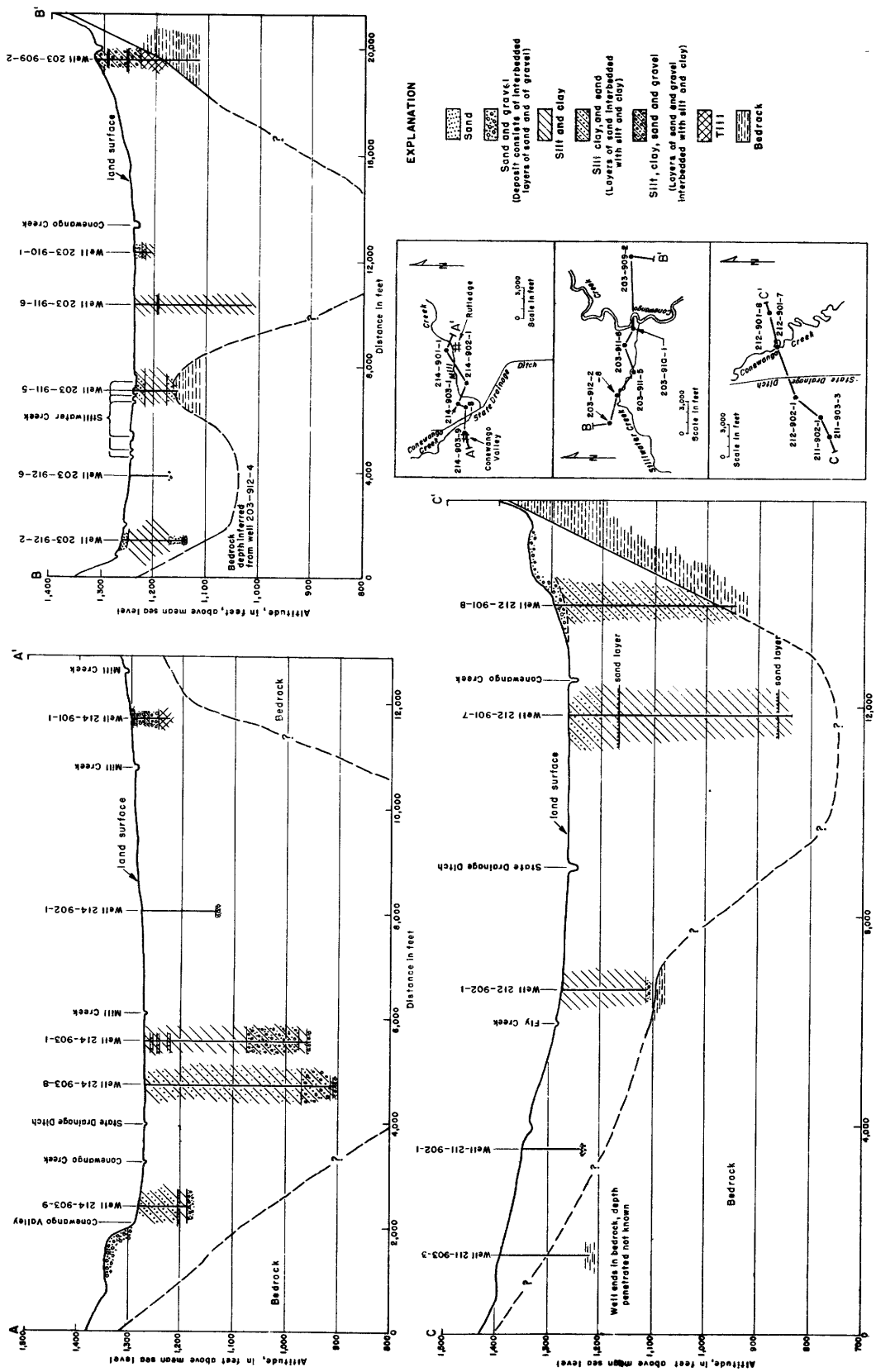


Figure 34.--Geologic sections across the Conewango Creek valley.

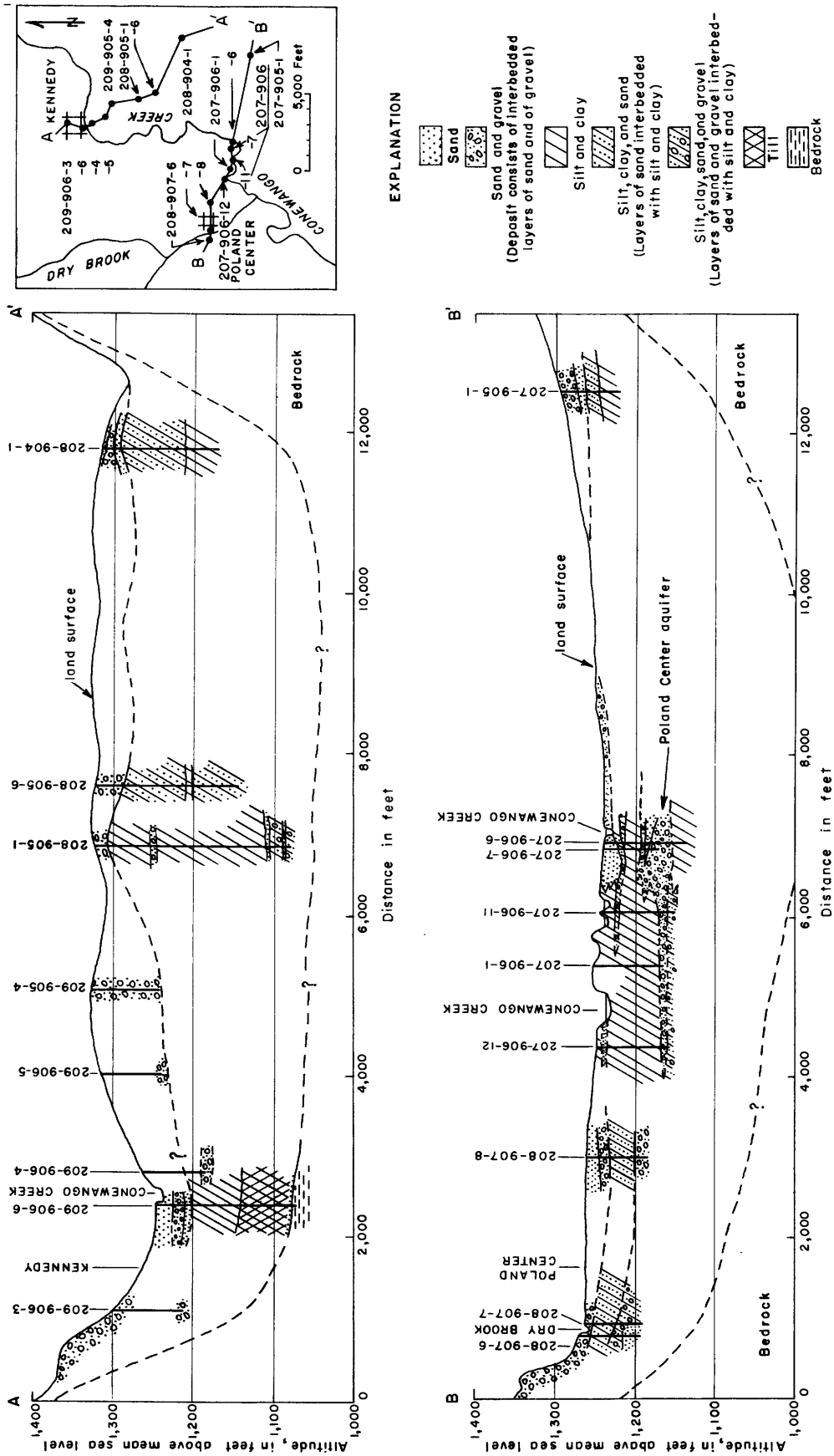


Figure 35.--Geologic sections through the valley-fill deposits near Kennedy and Poland Center.

Several wells in the village of Cherry Creek tap sand and gravel deposits at depths of 35 to 60 feet. The sand and gravel is interbedded with silt and clay which confines the water under pressure. Wells 217-905-2 and -3, east of the village, penetrate sand and gravel at depths of 95 and 180 feet, respectively. No wells are known to exist further to the east in the valley so the eastward extent of the sand and gravel layers of the Cherry Creek delta is not known. Water levels in the portion of the delta downstream from well 217-906-2 are above land surface. However, when the village well is pumped at a rate of 100 gpm, the other wells in the delta are reported to cease flowing. This indicates that the individual layers of sand and gravel, and silt and clay are rather extensive. The principal supply of the village of Cherry Creek is spring 217-908-1Sp (actually several springs). Well 217-906-2 is used in the summer as an auxiliary supply. The water use by the village averages about 90,000 gpd.

Only a few records of wells were obtained in the vicinity of Mud Creek. These indicate that sand and gravel underlies the valley floor (pl. 2). Well 215-902-1 in the Conewango Creek valley immediately south of Mud Creek penetrated only a thin layer of sand at depths of 246 to 249 feet. Because Mud Creek is a relatively large tributary, it could be expected to have a moderate-sized delta with thick permeable layers extending past well 215-902-1. The fact that such layers were not found suggests that the high area immediately east of the well deflected the deposition of the creek to the west and relatively little deltaic deposition occurred in the vicinity of the well.

The character of the deposits in the Conewango Creek valley in the vicinity of Mill Creek are probably better known than in any other part of the upper valley. As shown in plate 2, records were obtained for several wells in the valley between the villages of Conewango Valley and Rutledge (now known as Conewango) as well as at the villages themselves. Section A-A' in figure 34 shows the character of the deposits penetrated by those wells for which logs were obtained. The wells at Conewango Valley are generally less than 100 feet deep and penetrate what is believed to be a deposit of sand and gravel that was laid down partly by the ice along the side of the valley and partly by the small stream that flows out of the uplands west of the village. Well 214-903-9 has been pumped at a rate of 150 gpm with a drawdown of 9 feet. The transmissibility of the layer penetrated by the well is believed to be about 30,000 gpd per square foot.

The wells at Rutledge penetrate sand and gravel deposits of the Mill Creek delta. Wells 214-903-1, and -8, near the west side of the Conewango Creek valley, and well 214-902-1, near the center of the valley penetrate sand and gravel layers believed to be a part of the Mill Creek delta. Evidence for this is that the layers occur at a greater and greater depth to the west. In looking at the section it is important to note that water wells are generally drilled only to the depth required to obtain the desired quantity of water. Therefore, the sand and gravel penetrated by well 214-903-8 is believed to be present at the site of wells 214-903-1 and 214-902-1. However, the sand and gravel at well 214-902-1 terminates east of well 214-903-1 and, similarly, the sand and gravel layers interbedded with silt and clay between altitudes of 980 and 1,080 feet at well 214-903-1 terminate east of well 214-903-8. The fact that the materials penetrated by wells 214-903-1 and -8 are a part of the Mill Creek delta is also

substantiated by chemical quality data. It may be observed in table 5 that water from these wells is of similar chemical composition to the water from well 214-902-1 but is markedly different in composition from the water from well 214-903-7 which is near and penetrates the same deposits along the side of the valley as well 214-903-9 (fig. 34).

The wells near the center of the valley flow above land surface. The static water level of well 214-903-8 was 10 feet above land surface when measured in October 1961. The flow of the well was measured by the driller, Merle Cady, and found to be 200 gpm from the open 6-inch casing. (The flow of 85 gpm reported in table 6 represents the flow from two small-diameter outlets.) The yield of the well suggests a transmissibility of about 40,000 gpd per square foot for the layer penetrated by the well.

The valley of Clear Creek is underlain by permeable deposits of sand and gravel in hydraulic contact with the creek. These deposits appear to be about 40 feet thick in most of the area from Ellington to the main Conewango Creek valley. They are underlain either by till or mixed deposits of till and stratified deposits. The sand and gravel deposits extend on the surface into the Conewango Creek valley nearly to the tracks of the Erie Railroad. Layers of sand and gravel interbedded with, and overlain by, silt and clay extend eastward across the entire width of the valley. Wells near the center of the valley obtain water from a sand and gravel layer at a depth of about 90 feet (well 213-902-3). Further east in the valley, wells must be drilled to depths of 150 to 200 feet. Wells at a group of summer camps along Conewango Creek in quadrangle 212-901 (pl. 2), penetrate layers of sand and gravel at depths of 125 to 130 feet which are believed to be a part of the Clear Creek delta.

Most of the wells located on the flat, central portion of the upper Conewango Creek valley are flowing artesian wells. Most of these wells are permitted to flow continuously, both to prevent the water in the pipes from freezing in the winter, and because the owners believe that if the flow were stopped the yield would be reduced. The flow of the wells individually is not large--the largest measured flow being 85 gpm--but the total annual discharge of all the wells is substantial. In fact, a conservative estimate of the total discharge would be 100 million gallons per year.

In summary, sources of ground water in the upper Conewango Creek valley consist of sand and gravel deposits laid down as deltas where streams enter the valley and from discontinuous sand and gravel deposits along the sides of the valley that are not associated with streams. Four of the streams entering the valley: Cherry Creek, Mud Creek, Mill Creek, and Clear Creek, are moderate-size streams that have built moderately large deltas. Deep-lying layers of sand and gravel associated with these deltas extend nearly the entire width of the valley.

The sand and gravel deposits in the tributary valleys and in the deltas appear to be moderately to highly permeable and to be in excellent hydraulic contact with the streams crossing them. Because these streams drain relatively large areas they have substantial flows. When this fact is considered, together with the large volume of the sand and gravel in the valleys and in the deltas, it is apparent that substantial quantities of ground water can be developed in the upper Conewango Creek valley. To make

reliable estimates of the perennial yield of the delta deposits, more data is needed on the extent, thickness, and character of the deposits and the seasonal variations in the flow of the streams.

The flow of Clear Creek has been measured several times, both as a part of this study and during previous studies, at several sites between the villages of Clear Creek and Ellington. These measurements show that substantial quantities of water infiltrate from the creek into the sand and gravel deposits. Most of this water returns to the creek at the eastern edge of the delta (near the Erie Railroad tracks). Correlation of these measurements with the continuous streamflow record of Conewango Creek at Waterboro indicates a well sustained base-flow discharge as would be expected from purely geologic considerations. Therefore, for purposes of estimating the perennial yield of the sand and gravel deposits, it may be safe to assume that the runoff of the tributary streams, in gpd per square mile, is the same as that of Conewango Creek which is shown in figure 29.

Obviously, any estimate of the perennial yield of the sand and gravel deposits of the upper Conewango Creek valley made on the basis of present data is subject to substantial error. However, even the rough estimates possible at this time should be informative and useful with respect to future studies. The perennial yield of aquifers in an area, as noted in the earlier discussion of the Cassadaga Creek valley, may be expressed in terms of stream runoff from the area. As was pointed out in that discussion, the value cannot exceed the average annual flow of 1.1 mgd per square mile which on Conewango Creek is the flow equaled or exceeded 31 percent of the time (fig. 29). It may, in fact, be only a small part of the average annual flow in areas where relatively little water is in storage in aquifers. Because of the relatively high sustained base flow of Conewango Creek (and, therefore, presumably of its principal tributaries) which indicates substantial ground-water storage, it is believed that a perennial yield of 300,000 gpd per square mile would be a reasonable value. It may be observed in figure 29 that this is the flow equaled or exceeded about 65 percent of the time. Estimates of ground-water yields based on this value for the principal tributary valleys are shown below:

Valley	Approximate drainage area 1/ (square miles)	Estimated ground-water yield (gallons per day)
Cherry Creek	11	3,300,000
Mud Creek	15	4,500,000
Mill Creek	10	3,000,000
Clear Creek	32	9,600,000

1/ Includes area of principal stream and of unnamed tributaries flowing over sand and gravel deposits in same valley.

MIDDLE CONEWANGO CREEK VALLEY

The middle Conewango Creek valley, as used in this discussion, includes the area from the intersection of the State drainage ditch and Conewango Creek, 2 miles northeast of Waterboro, to the vicinity of Kennedy. The unconsolidated deposits in this portion of the valley are shown in plates 1 and 2. This segment of the valley represents the meeting ground of the ice tongues that advanced simultaneously down the Conewango and Cassadaga Creek valleys. It, therefore, is not as deeply cut into the bedrock as the upper and lower segments. The width of the bedrock valley is roughly indicated by the present extent of sand and gravel, mixed, and silt and clay deposits on the plates. It is generally about a mile wide except southeast of Kennedy where it narrows to about half a mile. The depth to bedrock in well 209-906-6 at Kennedy is 170 feet below land surface. The depth is doubtless greater both to the northeast and southwest.

The unconsolidated deposits in the valley consist of till lying directly on the bedrock. The till is overlain by a thick section of silt and clay which is, in turn, overlain by deposits of sand and gravel and mixed deposits. Conewango Creek has cut its present channel down into the sand and gravel and, in places, into the underlying silt and clay. Thus, the surficial sand and gravel and the mixed deposits now occur as relatively flat-topped "terrace-like" deposits along the present narrow valley of the creek. Many of the features described above may be seen on section A-A' in figure 35.

The "terrace-like" deposits of sand and gravel receive recharge both from precipitation and from overland runoff from the adjacent uplands. However, the deposits also usually bottom above the level of the creek and are rapidly drained both directly to the creek and by seepage around the margins of the deposits. During most summers only a thin saturated zone near the base of the deposits may be present. Spring 209-903-1Sp is an example of the water being discharged from this thin saturated zone. The spring which drains the terrace of sand and gravel to the north was flowing at a rate of about 60 gpm on August 25, 1961. The substantial discharge of the spring suggests that the aquifer supplying it is quite permeable. Probably the most effective development of many of these high-level deposits would be by utilizing such springs.

Sand and gravel deposits extend for a short distance below the level of Conewango Creek in parts of the area. As shown in figure 35, such deposits extend to a depth of about 30 feet at Kennedy. Similar conditions seem to exist in the vicinity of Waterboro. Although the areal extent of these deposits below the level of the creek is quite small, good hydraulic contact with the creek appears to exist. This would allow water to be derived from the creek by infiltration. The flow of Conewango Creek at Waterboro is at least 31 mgd 90 percent of the time. Therefore, it may be possible to obtain moderate perennial yields from the sand and gravel deposits where they occur below creek level.

Wells in most of the mixed deposits usually have low yields as indicated in plates 3 and 4. The reasons for these low yields are that the sand and gravel in these deposits is of small areal extent and is interbedded with relatively impermeable till. One outstanding exception to this is well 208-900-1 which is one of the public supply wells developed by the village

of Randolph. The yield of this well is about 200 gpm from a gravel deposit 30 feet below land surface. In this mixed deposit it appears that the aquifer has an excellent source of recharge in a higher portion of the deposit where it may be in contact with the small stream that flows through the area.

POLAND CENTER AQUIFER

One of the largest and most important aquifers in the Conewango Creek valley occurs near Poland Center in the area shown in figure 36. The extent of the aquifer as shown in the figure is only the known extent based upon present information. The Poland Center aquifer consists of a deposit of sand and gravel ranging in thickness from 5 to 70 feet in the area shown in figure 36, and overlain by from 10 to 80 feet of fine-grained material. The greatest known thickness of the aquifer is at a recent (December 1964) test well drilled for the city of Jamestown near the east bank of Conewango Creek about 2,000 feet northeast of well 207-906-6. (See figure 36.) The top of the aquifer is only 14 feet below land surface at this site. The aquifer thins to the southwest and west and terminates south of well 208-906-2. Its extent to the east and southeast is not known. However, the aquifer is not present in the vicinity of well 208-905-7. A test well drilled by the city of Jamestown near the hamlet of Clark penetrated sand and gravel which may be an extension of the aquifer. A section through part of the deposit is shown in figure 35.

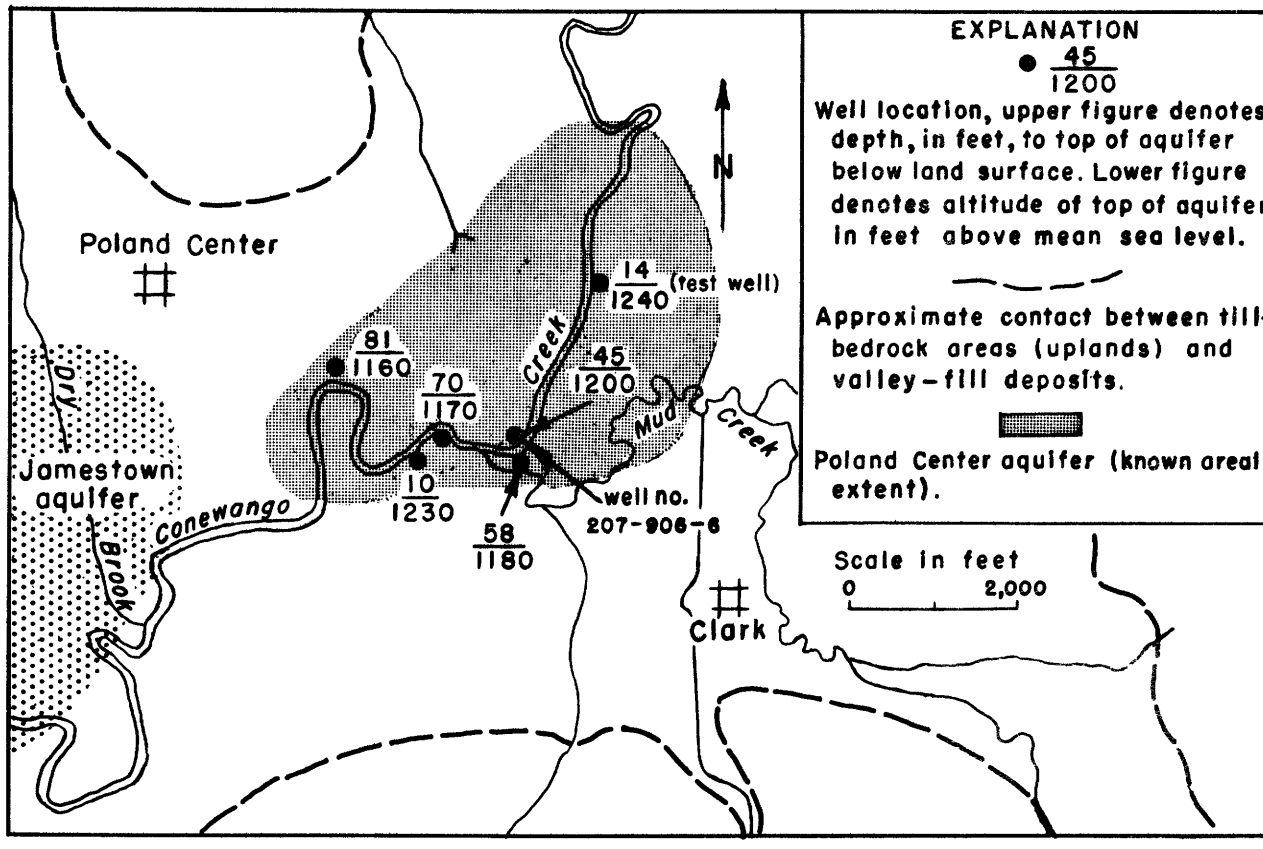


Figure 36.--Known areal extent of the Poland Center aquifer.

The sand and gravel aquifer at the Poland Center site was originally thought to have been deposited at the margins of the ice that once occupied the area. On this basis it was thought that the deposit might represent an outer highly irregular fringe of the Jamestown aquifer (Crain, 1963, p. 4). However, the recent drilling by the city of Jamestown indicates little or no connection with the Jamestown aquifer.

The origin of the deposit is of prime importance in determining its extent and variations in its water-bearing character. However, the best guess that can be made at this time is that it was deposited near the margin of the ice sheet as the ice melted back from the vicinity of Kennedy. It may, therefore, be related in origin (but recent test drilling indicates not now hydraulically connected) to the surficial sand and gravel deposit underlying the area extending southeast from Kennedy. It is also possible that the aquifer extends southeast of the Poland Center site and gradually merges into the delta of Mud Creek. (This is not the same Mud Creek discussed in the upper Conewango Creek valley.) With respect to a possible hydraulic connection between the Poland Center aquifer and the Mud Creek delta, it should be noted at this point that this delta appears to be composed of a veneer of sand and gravel about 20 feet thick which is underlain by clay and additional beds of sand and gravel. The aquifer may represent a northward extension of the sand and gravel layer of the delta, but evidence available at the present time is not sufficient to determine this.

Knowing that the aquifer in the Poland Center area was fairly large and in a favorable position for recharge by stream infiltration, information on the hydraulic characteristics was needed to evaluate its potential as a source of water supply. Therefore, a pumping test on the aquifer was conducted during the fall of 1962. The test consisted of pumping well 207-906-6 at a rate of 524 gpm during a 48-hour and 10-minute period from October 31 to November 2, 1962. During the test, water-level observations were made in the pumping well and in wells 207-906-7 and -8 which are located 77 feet and 600 feet, respectively, from the pumping well. After pumping was stopped, the recovery of water levels was also measured in all three wells to verify the drawdown data.

At the start of the test the stage of Conewango Creek was rising. The stage peaked during the test and the creek level declined for the remainder of the test and during the recovery period. The water level in the aquifer apparently responded to these changes in the creek level. The recovery portion of the test was, therefore, used for analysis because it was easier to correct for the change in static water level in the aquifer in response to the change in trend of the creek stage.

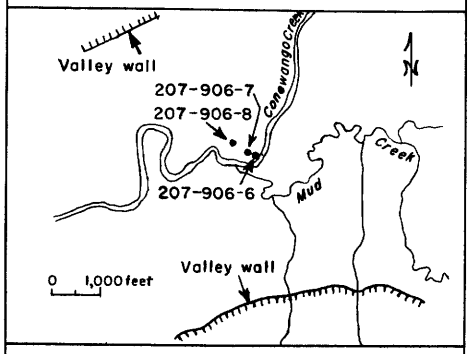
Figure 37 shows basic data concerning the pumping test and an analysis of the recovery data. The recovery measurements were corrected for residual drawdown and the change in static water level, then plotted against time, in minutes, on logarithmic paper.

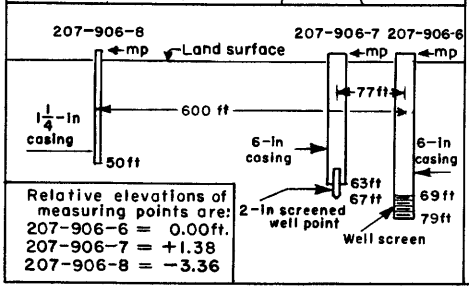
Matching the test data with the Theis type curves yielded values of about 570,000 gpd per foot and 620,000 gpd per foot for the transmissibility of the aquifer. The storage coefficients were computed for the two wells to be 0.025 and 0.00054. As indicated by the dashed line in figure 37, the water level in well 207-906-7, 77 feet from the pumping well, had fully

Pumping test of Oct. 31-Nov. 2, 1962
near Poland Center

Well 207-906-6 was pumped at a rate of 524 gpm for 48 hours and 10 minutes. Water levels were measured in wells 207-906-7 and -8 during and after pumping. Table at right lists selected data from the recovery portion of the test. The recovery measurements were corrected for residual drawdown and changes in static level.

The pumped well was located about 59 feet west of Conewango Creek. The aquifer consists of sand and gravel from 45 to 81 feet at well 207-906-6.





Relative elevations of measuring points are:
207-906-6 = 0.00ft.
207-906-7 = +1.38
207-906-8 = −3.36

Well 207-906-7			Well 207-906-8		
Time (minutes)	Depth to water below m. p. (feet)	Corrected recovery (feet)	Time (minutes)	Depth to water below m. p. (feet)	Corrected recovery (feet)
0	10.24	0	0	5.51	0
1	10.15	.09	1	5.47	.04
2	10.12	.12	2	5.43	.08
3	10.10	.14	3	5.42	.09
4	10.08	.16	4	5.39	.12
5	10.07	.17	5	5.38	.13
6	10.05	.19	6	5.36	.15
7	10.04	.20	7	5.35	.16
8	10.03	.21	8	5.33	.18
9	10.02	.22	9	5.32	.19
10	10.01	.23	10	5.31	.20
11	10.00	.24	11	5.31	.20
12	10.00	.24	12	5.30	.21
13	9.99	.25	13	5.29	.22
14	9.98	.26	14	5.29	.22
15	9.98	.26	15	5.28	.23
16	9.97	.27	16	5.28	.23
17	9.96	.28	17	5.27	.24
18	9.96	.28	18	5.27	.24
19	9.96	.28	19	5.26	.25
20	9.95	.29	20	5.25	.26
22	9.94	.30	22	5.24	.27
24	9.93	.31	24	5.24	.27
26	9.93	.32	26	5.23	.28
28	9.92	.32	28	5.23	.28
30	9.92	.33	30	5.22	.29
36	9.90	.34	36	5.20	.31
43	9.87	.38	40	5.19	.32
47	9.86	.38	46	5.18	.33
52	9.86	.39	50	5.17	.34
57	9.84	.41	56	5.15	.36
63	9.83	.42	60	5.15	.36
70	9.82	.43	66	5.14	.37
77	9.81	.44	70	5.14	.37
85	9.80	.45	76	5.13	.38
93	9.79	.46	80	5.12	.39
101	9.78	.47	86	5.11	.40
111	9.77	.49	90	5.11	.40
121	9.76	.50	100	5.10	.42
132	9.75	.50	110	5.09	.43
146	9.74	.52	120	5.08	.44
160	9.73	.53	131	5.07	.45
176	9.72	.54	140	5.07	.45
193	9.72	.55	152	5.06	.46
208	9.71	.56	160	5.05	.47
225	9.71	.56	177	5.05	.48
253	9.70	.57	221	5.04	.49
274	9.70	.58	241	5.03	.50
313	9.69	.59	275	5.02	.52
409	9.69	.61	302	5.02	.52
469	9.69	.61	342	5.01	.53

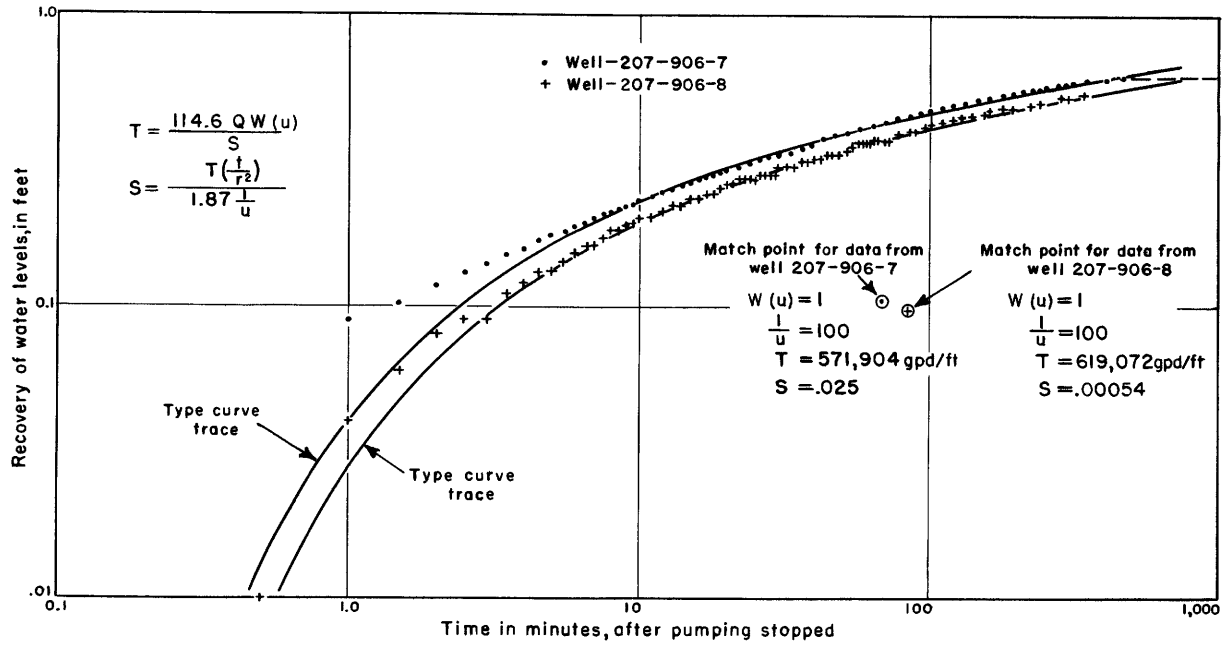


Figure 37.--Time-recovery curves and basic data from a pumping test near Poland Center.

recovered after about 350 minutes. In other words, after 350 minutes the water level in the well paralleled the changes in the stage of Conewango Creek. This is clearly seen in figure 38 which shows water-level fluctuations in the well and in Conewango Creek, both at Waterboro and at the site of the pumping well.

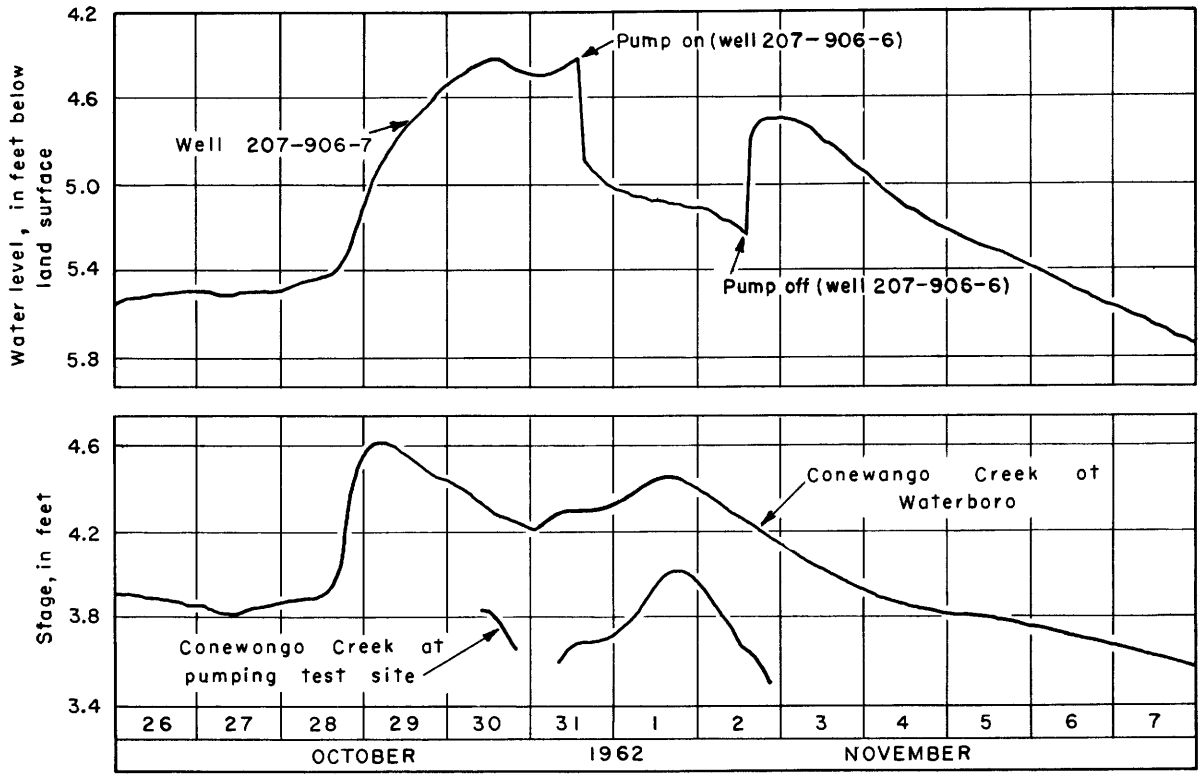


Figure 38.--Well 207-906-7 and Conewango Creek.

It may be observed in figure 37 that the water levels for both wells plot above the type curves during the first few minutes of recovery. This departure above the type curve indicates a faster rate of recovery than would be predicted by the Theis equation. The reason for this departure is not known but may be due to the fact that the aquifer is stratified and observation well -7 was finished with only 3 feet of screen and well -8 was not screened at all. Thus, during the early minutes of recovery the wells reflected the change in water level in discrete permeable layers and not the change in the aquifer as a whole.

In conclusion, the test showed that the sand and gravel deposit at the Poland Center site has a transmissibility of about 600,000 gpd per foot. The aquifer appears to be rather freely connected hydraulically to Conewango Creek, probably along stretches of the channel where the silt and clay confining bed has been eroded away. The position of such stretches is not known. However, a rough calculation based on the recovery data for well 207-906-7 in figure 37 indicates the presence of a recharge area about 800 feet from the well. Because of the shallow depth to the aquifer at the test well (fig. 36), it would appear that this recharge area is between the test well and well 207-906-6.

To determine the perennial yield of the aquifer, additional data must be obtained on its extent and water-bearing characteristics, on the character and continuity of the confining bed, and on the degree of hydraulic connection between the creek and the aquifer. However, the data presently available suggest that its yield may be a few million gallons per day.

LOWER CONEWANGO CREEK VALLEY

The lower Conewango Creek valley includes the main valley of Conewango Creek south of Poland Center and the larger tributary valleys except, as noted before, those of Cassadaga Creek and the Chadakoin River. The unconsolidated deposits underlying the surface of the valley are shown in plates 1 and 2. The yields of wells penetrating the different deposits are shown in plates 3 and 4.

The maximum thickness of the unconsolidated deposits in the main valley is not known but may be as much as 500 feet. As in the remainder of the Conewango Creek valley, most of the deposits are fine grained - consisting largely of silt and clay. A nearly continuous sand and gravel deposit fringes the eastern side of the valley. Other deposits of sand and gravel occur in the larger tributary valleys and in deltas where these streams enter the main valley. The eastern end of the Jamestown aquifer extends into the area between Falconer and Poland Center. However, because this aquifer has been discussed in detail in the section devoted to the Cassadaga Creek valley, it will not be discussed here.

The sand and gravel deposits that fringe the eastern side of the valley serve as sources of small water supplies. Most of these deposits are above the main valley and, thus, drain readily. The sand and gravel deposits in the tributary valleys and in the deltas are the most important sources of ground water in the lower Conewango Creek valley. The sand and gravel deposits in the tributary valleys are generally less than 20 feet thick. These deposits are favorably situated to receive stream infiltration and wells capable of yielding up to 100 gpm can probably be developed in them in many places.

The deltas built by Stillwater Creek, Frews Run, and the other tributary streams are relatively small and do not contain either thick or extensive deposits of sand and gravel. Numerous test holes drilled in the village of Frewsburg indicate that considerable silt and clay is intermixed with the sand and gravel. This suggests that the sediments transported by Frews Run were largely fine grained. In other words, relatively little sand and gravel-sized material was available in the area drained by the stream. This is not unexpected in view of the glacial history. The same situation is believed to prevail throughout the lower Conewango Creek valley.

Water is obtained from sand and gravel by the public supply wells at Frewsburg. The village obtains about 150,000 gpd from two wells (204-909-1 and -2) along Conewango Creek about a mile north of the village. (Since the completion of this study the village has carried out extensive test-drilling operations and has constructed a third supply well north of the creek.) These wells penetrate a layer of sand and gravel at depths of

about 35 feet. The layer is about 5 feet thick. It is overlain by thinly interbedded silt and clay, and sand. It is underlain by silt and clay. A test well drilled by the Geological Survey about a mile west of Frewsburg (203-911-6) penetrated a layer of sand and gravel between depths of 45 and 47 feet. From 47 feet to the bottom at 225 feet, the well penetrated only silt and clay. The layer of sand and gravel is probably the same layer penetrated by the Frewsburg wells.

The origin of this layer is not obvious from the data available at this time. It would appear at first glance that the layer is a part of the delta of Frews Run. If this were the case, test holes 203-909-1 and -2 drilled in the village of Frewsburg should have penetrated thick layers of gravel. However, as noted earlier, such layers were not found. Therefore, the layer of sand and gravel penetrated by the Frewsburg wells and by the Geological Survey test well may represent a thin layer of "outwash" laid down along the margins of the ice as it melted up the valley. If this is correct, the layer is geologically equivalent to the Jamestown aquifer. The eastern part of the sand and gravel deposit along Kiantone Creek may be a surface exposure of this layer.

In order to develop a better understanding of the hydrology of the aquifer supplying the Frewsburg wells, a pumping test was conducted on well 204-909-1. The well was pumped at a rate of approximately 145 gpm for 12 hours and 10 minutes. Drawdowns of water levels were measured in wells 204-909-2 and -5, located 150 and 50 feet from the pumping well, respectively.

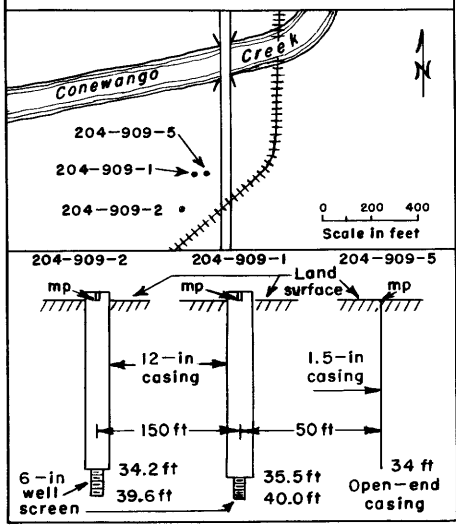
The basic data concerning the test and an analysis of the water levels are shown in figure 39. It will be noted that a plot of the drawdowns against time, in minutes, on logarithmic paper changes from a curve to very nearly a straight line after about 100 minutes of pumping. It was found that these plots matched the leaky type curves after about 4 minutes pumping. Because a leaky confining bed is consistent with the geologic situation, the test was analysed according to the leaky artesian aquifer method previously discussed.

On the basis of the type curve matches, the transmissibility of the aquifer appears to range from about 6,900 to about 7,400 gpd per foot. The storage coefficients were computed to be 0.00006 and 0.0004 which indicates artesian conditions. The permeability of the confining bed was calculated to range from 2.2 to 0.26 gpd per square foot. The analysis of the test, therefore, suggests that the withdrawals of the village of Frewsburg are supplied by slow movement of water through the confining bed from Conewango Creek and the nearby swampy areas.

Pumping test of November 8, 1962
at Frewsburg, N.Y.

Well 204-909-1 was pumped at an average rate of 145 gpm while drawdowns were measured in wells 204-909-5 and 204-909-2, located 50 feet and 150 feet from the pumped well, respectively. Table at right lists selected data from the test.

The aquifer consists of a sand and gravel deposit at a depth of about 35 to 40 feet below land surface. Measuring point (m. p.) on well 204-909-5 is top of casing, 1.9 feet above land surface. Measuring point of well 204-909-2 is slot in casing 0.25 feet below land surface.



Well 204-909-5			Well 204-909-2		
Time (minutes)	Depth to water below m. p. (feet)	Drawdown (feet)	Time (minutes)	Depth to water below m. p. (feet)	Drawdown (feet)
0	7.75	0	0	5.55	0
1	8.89	1.14	1	6.62	1.07
2	10.01	2.26	2	8.37	2.82
3	11.26	3.51	3	8.80	3.25
4	12.42	4.67	4	9.14	3.59
5	13.08	5.33	5	9.45	3.90
6	12.99	5.24	6	9.75	4.20
7	13.68	5.93	7	9.98	4.43
8	13.88	6.13	8	10.21	4.66
9	14.06	6.31	9	10.40	4.85
10	14.21	6.46	10	10.61	5.06
11	14.36	6.61	11	10.73	5.18
12	14.51	6.76	12	10.86	5.31
13	14.79	7.04	13	11.01	5.46
15	14.85	7.10	14	11.11	5.56
16	14.92	7.17	15	11.22	5.67
17	15.03	7.28	16	11.32	5.77
18	15.11	7.36	17	11.41	5.86
19	15.19	7.44	18	11.50	5.95
20	15.27	7.52	19	11.57	6.02
22	15.39	7.64	22	11.81	6.26
24	15.52	7.77	24	11.93	6.38
26	15.61	7.86	26	12.05	6.50
28	15.71	7.96	28	12.12	6.57
32	15.87	8.12	32	12.30	6.75
36	16.00	8.25	36	12.42	6.87
40	16.11	8.36	40	12.55	7.00
46	16.24	8.49	46	12.68	7.13
50	16.29	8.54	50	12.76	7.21
60	16.46	8.71	60	12.92	7.37
70	16.52	8.77	70	13.01	7.46
80	16.60	8.85	80	13.08	7.53
90	16.64	8.89	90	13.13	7.58
100	16.70	8.95	100	13.18	7.63
120	16.75	9.00	120	13.25	7.70
140	16.80	9.05	140	13.29	7.74
160	16.81	9.06	160	13.31	7.76
180	16.85	9.10	180	13.35	7.80
200	16.84	9.09	200	13.36	7.81
220	16.89	9.14	220	13.39	7.84
260	16.92	9.17	270	13.39	7.84
300	16.87	9.12	300	13.41	7.86
320	16.85	9.10	330	13.41	7.86
362	16.87	9.12	361	13.40	7.85
440	16.87	9.12	450	13.40	7.85
500	16.85	9.10	510	13.39	7.84
560	16.83	9.08	570	13.37	7.82
620	16.82	9.07	660	13.32	7.77
730	16.78	9.03	726	13.35	7.80

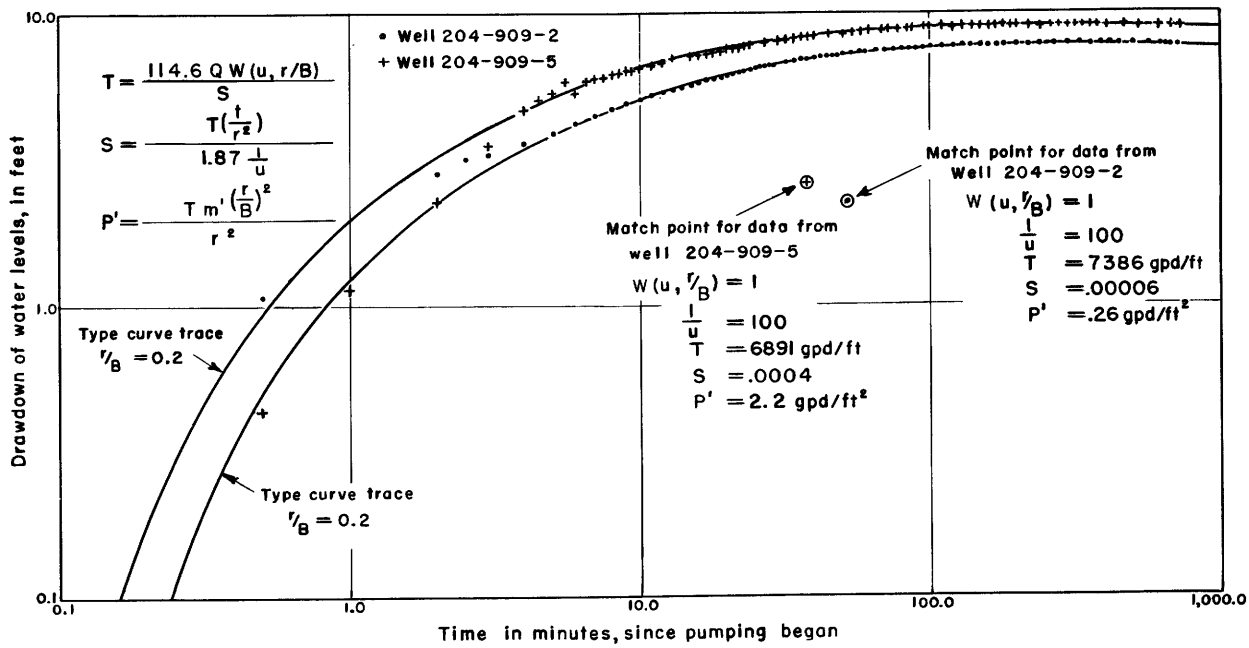


Figure 39.--Time-drawdown curves and basic data from a pumping test at the Frewsburg well field.

WELL CONSTRUCTION AND ITS RELATION TO YIELD

Several types of well construction are used in the Jamestown area. The type of well construction selected in any one location is influenced by the character of the water-bearing deposit, the cost of construction, and the amount of water required. The most common types of wells used in the area, from the standpoint of construction, are dug, drilled, driven, and jetted.

DUG WELLS

Dug wells are particularly effective in the withdrawal of water from till and other fine-grained (relatively impermeable) material. They are constructed by excavating a large hole which usually ranges from 24 to 36 inches in diameter and from 10 to 25 feet deep. The hole is then lined with stone or a "porous" tile. When stone is used, it is generally cemented only at the points of contact of the stones and, thus, allows water to seep in the well from the entire wall area. Similarly, "porous" tile contains numerous small openings which permit water to seep through the walls and into the well. The large diameter of dug wells provides a large reservoir in which ground water accumulates when the well is not being pumped. Even though the water-bearing material may be relatively impermeable, this storage provides enough water for short periods of large demand. For example, each foot of water in a dug well 36 inches in diameter represents a storage of 50 gallons of water. If the well contains 5 feet of water, the storage amounts to 250 gallons. This storage would be sufficient to supply household demands during periods of heavy pumpage even though the continuous long-term yield of the well might be on the order of half a gallon per minute or less. Overnight and during other periods when the well is not in use, the storage is replenished.

The topographic position of a dug well affects its yield. Because a dug well cannot be excavated for any great distance below the water table, those that are located on hilltops or the higher slopes tend to go dry during dry summers. This is caused by the larger fluctuation of the water table in these areas. In many places these wells can be deepened while the water table is low.

The advantages of dug wells are (1) they may be cheaply constructed, and (2) they may be used to obtain water from a poor aquifer. The disadvantages are (1) they may go dry during long dry periods, (2) they will not yield a large quantity of water for long periods of continuous pumpage, and (3) they are susceptible to pollution by surface water.

DRILLED WELLS

Drilled wells are constructed by excavating a hole with either a cable-tool or rotary drilling machine. The cable-tool method is by far the most common in the Jamestown area. The hole is drilled by raising and dropping a large tool which pulverizes the rock. At frequent intervals this material is bailed from the hole. As the well progresses, steel casing is installed to keep the hole open. Diameters of drilled wells for domestic purposes usually range from 4 to 8 inches. Those wells used for industrial or public supplies are often 12 to 24 inches in diameter. A drilled well is finished differently depending on whether it is ended in bedrock or in unconsolidated material. Drilled wells ending in bedrock are cased to the top of the rock and the drilling then continues without casing. This leaves the hole open throughout the bedrock so that water can freely enter the well from any fractures or joints penetrated by the hole. Each of the fractures or joints penetrated may add a small amount of water to the total yield. Drilled wells ending in unconsolidated deposits are cased the entire depth of the well or finished with a well screen. Most drilled wells in sand and gravel used for domestic supplies are finished with open-bottomed casing. This allows water to enter only through the open end of the casing. Well screens are installed in drilled wells which are intended to supply large quantities of water. The size of the openings in the screen is selected on the basis of the grain sizes found in the aquifer. Some drilled wells are also finished by perforating the casing which serves much the same purpose as a well screen.

The advantages of drilled wells are that sustained yields are generally greater than those of dug wells and they are less subject to pollution by surface water. Disadvantages are that they are relatively expensive to construct and they cannot be successful in fine-grained, relatively impermeable aquifers.

DRIVEN WELLS

Some of the least expensive and easiest wells to install are driven wells. These wells are widely used in areas where sand and gravel is at or near land surface. They are constructed by using a heavy weight to drive a length of casing, equipped with a well point, into the ground. The diameter of the casing is usually from 1 1/4 to 2 inches, and the well points contain a screened section. Because driving becomes difficult with increasing depth, most driven wells are less than 30 feet deep. However, a few driven wells in the Jamestown area are reported to be more than 100 feet deep. Because of their small diameters, driven wells are usually equipped with suction pumps which limits the amount of drawdown available. The small diameter of the casing does not provide any appreciable storage. Because of these limitations, the yields from driven wells are usually fairly low.

JETTED WELLS

A few wells in the Jamestown area have been constructed by the jetting method. This method, as used locally, consists of pumping water through a small-diameter casing (1 1/4 to 2 inches in diameter) which washes a hole

through unconsolidated material. As one length of casing is washed down another length is attached, and the process is continued until the well is at the desired depth. The casing may then be left in place or pulled and replaced with another. Jetting is very effective, inexpensive, and fast in moving through fine-grained unconsolidated material. However, it is difficult to jet through coarse-grained material because the jetted water is usually carried away into the deposit. Depths of jetted wells have a great range, depending on the character of the subsurface material. Some jetted wells over 300 feet deep are reported in the Jamestown area. The yields, sizes, and characteristics of jetted wells are very similar to those of driven wells.

QUALITY OF WATER

Two distinctly different types of ground water are found in the Jamestown area. One of these types may be termed fresh water and the other mineralized water.

The fresh water is characterized by a chloride content of less than 10 ppm (parts per million) and a concentration of dissolved solids of 100 to 300 ppm. (See following section for definition of ppm.) This water originates as precipitation in the area. The mineralized water is characterized by a chloride content of over 1,000 ppm and a concentration of dissolved solids of several thousand parts per million. Its mineral content makes it unfit for nearly all purposes. This water probably has originated in either of two ways: (1) as the result of the deep circulation of fresh ground water which dissolved portions of deep salt beds, or (2) as the result of the upward movement of saline (salty) water that was trapped in the bedrock during its deposition in Devonian times. The mineralized water moves upward along fractures and faults in the rock and, as it approaches the land surface, mixes with the fresh ground water.

Precipitation is water which has evaporated from the earth's surface from either land or water areas. The chemical constituents are left behind during evaporation and the resulting water vapor is essentially free of minerals. However, the air itself contains dust and chemical vapors. Small amounts of these chemicals are absorbed as the water vapor condenses and as the precipitation falls. Therefore, chemical constituents are present in the precipitation when it reaches the earth's surface. However, the major changes in chemical quality of the water occur after it reaches the land surface.

The identity of the chemical constituents actually present in the water will reflect the chemical composition and solubility of the rocks through which the water has traveled. Because the chemical composition of the earth materials may vary locally, both over short areal distances and with depth, the chemical composition of the ground water will also vary.

CHEMICAL CONSTITUENTS AND PROPERTIES

In order to determine the chemical composition of the ground water in the Jamestown area, samples of water were collected to reflect areal and vertical differences in quality. Table 5 contains standard complete chemical analyses of 12 wells and partial chemical analyses of 107 wells and springs. The complete analyses actually represent only the chemical constituents which are commonly determined in a water analysis. The partial analyses show a few selected constituents which are either important in the Jamestown area or serve as clues to the quality of the water as a whole.

Table 5.--Chemical analyses of ground water from the Jamestown area

Well or spring number: See "Well-Numbering System" in text for explanation. Springs are designated by "Sp" following the number.

Depth of well: All depths below land surface.
r - reported
all others measured

Water-bearing material: G - Gravel
S - Sand
S & G - Sand and gravel
B - Bedrock
T - Till

Remarks: All analyses by U.S. Geological Survey, Quality of Water Branch, unless noted otherwise.

(All results in parts per million except specific conductance, pH, and color)

Well or spring number	Date of collection	Depth of well (feet)	Water-bearing material	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness (as $CaCO_3$) Calcium, magnesium	Hardness (as $CaCO_3$) Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color	Remarks
200-917-3	6/ 8/61	20	S	--	--	--	--	--	---	---	--	10	--	--	190	132	--	289	---	--	H_2S.
201-909-2	8/16/61	r90	B	--	.12	--	--	--	---	---	--	94	--	--	439	96	--	738	---	--	H_2S.
-3	8/16/61	121?	B	--	1.0	--	--	--	---	---	--	114	--	--	496	143	--	821	---	--	Well contains oil and natural gas; water is obtained from bedrock of uncertain depth between outer and inner casing.
201-917-3	6/ 7/61	r75	S & G	--	.71	--	--	--	---	---	--	9.6	--	--	218	138	--	338	---	--	
-6	6/ 8/61	r156	B	--	2.8	--	--	--	---	---	--	2,420	--	--	4,440	1,090	--	7,560	---	--	Well contains oil and natural gas.
202-914-1	8/23/61	r167	B	--	.60	--	--	--	---	---	--	196	--	--	607	128	--	1,080	---	--	H_2S.
202-916-4	7/ 7/61	r188	B	--	.20	--	--	--	---	---	--	670	--	--	1,610	142	--	2,670	---	--	Well contains oil and natural gas.
202-925-1	10/ 8/62	r355	B	--	1.4	--	--	--	---	---	--	360	--	--	819	102	--	1,420	8.1	--	Well contains natural gas.
203-912-3	8/21/52	r65	G	9.3	.10	36	6.3	11		151	8.5	5.0	.2	.2	147	116	0	254	7.7	5	
-5	8/ 3/61	r101	G	--	.19	--	--	--	---	---	--	34	--	--	258	115	--	427	---	--	H_2S.
-6	8/16/61	r75	S & G	--	.43	--	--	--	---	---	--	3.4	--	--	126	86	--	193	---	--	H_2S.
203-913-1	8/18/61	r30	S & G	--	.13	--	--	--	---	---	--	.6	--	--	208	158	--	323	---	--	
-4	8/17/61	r43	G	--	.44	--	--	--	---	---	--	156	--	--	470	174	--	892	---	--	Well may be obtaining some water from bedrock.
204-909-1	8/21/52	r44	G	9.2	.05	61	12	6.4	1.7	206	23	7.2	0.1	20	249	202	33	416	7.6	2	
-2	8/21/52	r43	G	35	.09	64	9.6	6.0	1.4	199	34	5.7	0	9.5	259	199	36	399	7.7	5	
205-907-3	4/ 2/62	r350	B	--	.19	--	--	--	---	---	--	4.0	--	--	159	132	--	266	---	--	H_2S.
205-909-1	6/15/61	r88	G	--	.80	--	--	--	---	---	--	240	--	--	1,030	321	--	1,700	---	--	H_2S.
205-911-1	11/23/60	74	G	--	--	--	--	--	---	---	--	14	--	--	147	82	--	242	---	--	Well may be obtaining much of its water from bedrock.
205-922-3	10/ 9/62	r91	G	--	.91	--	--	--	---	---	--	5.1	--	--	191	101	--	345	7.5	--	
206-908-1	8/21/52	r83	G	7.7	.82	26	2.7	13		117	1.5	4.2	0	.3	107	76	0	190	7.9	10	
-4	10/ 5/60	r32	S & G	--	--	--	--	--	---	---	--	8.1	--	--	441	313	--	680	---	--	
206-910-1	8/26/60	r103	S & G	--	--	--	--	--	---	---	--	4.8	--	--	163	140	--	271	7.5	--	

Table 5.--Chemical analyses of ground water from the Jamestown area (Continued)

Well or spring number	Date of collection	Depth of well (feet)	Water-bearing material	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness (as $CaCO_3$)		Specific conductance (micromhos at 25°C)	pH	Color	Remarks
																Calcium, magnesium	Noncarbonate				
206-911-1	8/26/60	r45	S & G	--	--	--	--	--	---	---	--	6.2	--	--	129	99	--	218	6.9	--	
-2	11/21/60	r84	G	--	--	--	--	--	---	---	--	8.8	--	--	291	230	--	475	---	--	
-5	3/28/62	r42	G	--	.03	--	--	--	---	---	--	64	--	--	402	228	--	662	---	--	
206-912-1	8/20/52	r45	G	9.9	1.6	59	12	14	2.4	191	51	15	0	.5	264	197	40	437	7.4	2	
-3	3/27/62	r34	G	--	.44	--	--	--	---	---	--	20	--	--	332	235	--	542	---	--	
-9	3/29/62	r26	S & G	--	.10	--	--	--	---	---	--	95	--	--	452	254	--	679	---	--	
206-915-4	3/21/62	r34	G	12	--	79	17	--	---	244	65	20	--	--	---	268	--	---	7.7	--	Analysis supplied by Hall Laboratories, Pittsburg, Pa.
207-906-6	8/ 7/62	79	S & G	9.3	.01	43	8.9	7.0	.7	163	13	2.8	.1	17	182	144	11	309	7.6	3.0	H_2S; manganese 0.03 ppm; carbonate 0 ppm.
207-908-3	9/ 5/62	99	S & G	11	.01	27	4.2	10	.5	106	24	2.0	.1	0	128	85	0	210	7.7	3	Manganese 0.01 ppm; carbonate 0 ppm.
207-909-5	11/22/60	r10	S	--	--	--	--	--	---	---	--	4.0	--	--	226	172	--	364	---	--	
207-910-1	8/26/60	r181	G	--	--	--	--	--	---	---	--	4.0	--	--	173	140	--	275	8.1	--	
-3	8/26/60	r103	G	--	--	--	--	--	---	---	--	3.2	--	--	152	124	--	252	7.6	--	
207-911-2	3/27/62	r10	S & G	--	--	--	--	--	---	---	--	71	--	--	---	220	--	---	---	2.8	Sulfite (SO_3) 200 ppm; phosphate (PO_4) 15 ppm; analysis supplied by American Manufacturing Company.
207-912-4	3/29/62	43	S & G	--	.12	--	--	--	---	---	--	19	--	--	400	278	--	572	---	--	
207-915-1	8/24/60	r111	G	--	--	--	--	--	---	---	--	6.6	--	--	247.0	190.0	--	403	7.7	--	
207-917-2	9/ /62	r40	G	--	--	--	--	--	---	---	--	120	--	--	---	222	--	---	7.5	--	Well may be obtaining water from bedrock; analysis supplied by Fluvanna Elementary School.
208-907-1	8/23/61	r30	S & G	--	.04	--	--	--	---	---	--	2.8	--	--	90	62	--	145	---	--	
208-910-2	11/22/60	r127	G	--	--	--	--	--	---	---	--	2.7	--	--	198	160	--	326	---	--	
208-912-2	6/11/47	r131	S & G	--	--	--	--	--	---	---	--	2.6	--	--	---	132	--	---	8.1	--	Analysis supplied by city of Jamestown.
-4	2/ 5/52	r147	S & G	6.1	.13	32	5.6	3.9	.7	100	24	2.6	0.1	0.3	127	103	21	214	8	1	Manganese 0.01 ppm; carbonate 100 ppm; turbidity 0.7 ppm.
-9	4/12/37	r491	S & G	--	1.4	--	--	--	---	---	--	350	--	--	750.0	132.0	--	---	7.6	18	Carbonate 12.0 ppm; alkalinity 188 ppm; turbidity 12 ppm; analysed by James M. Caird, Troy, N. Y.
-10	6/ 9/37	r574	S & G	--	.35	--	--	--	---	---	--	184	--	--	612	46.2	--	---	7.5	8	Carbonate 1 ppm; alkalinity 264 ppm; turbidity 15 ppm; analysed by James M. Caird, Troy, N. Y.
-11	4/25/47	r142	G	--	--	--	--	--	---	70	--	---	--	--	---	---	--	---	8.3	--	Carbonate 6.0 ppm; well abandoned because of turbidity and color; analysed by N.Y.S. Department of Health.
-21	11/11/41	r136	S & G	--	.30	--	--	--	---	---	--	5	--	--	140	130.9	--	---	8.1	--	Analysis supplied by city of Jamestown.
209-903-1Sp	8/25/61	--	S & G	--	.02	--	--	--	---	---	--	.0	--	--	172	154	--	299	---	--	

Table 5.--Chemical analyses of ground water from the Jamestown area (Continued)

Well or spring number	Date of collection	Depth of well (feet)	Water-bearing material	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness (as $CaCO_3$)		Specific conductance (micromhos at 25°C)	pH	Color	Remarks
																Calcium, magnesium	Noncarbonate				
209-906-6	11/ 6/62	175	B	--	3.4	--	--	--	---	---	--	110	--	--	450	107	--	770	7.4	--	H_2S.
209-911-1	8/20/52	r55	B	39	2.8	22	5.1	9.9	1.6	100	11	3.3	.5	1.1	158	76	0	186	7.4	12	
209-913-1	11/11/41	129	S & G	--	2.5?	--	--	--	---	---	--	8.0	--	--	160	109.4	--	---	7.7	30	Turbidity 15 ppm; nigh iron content may be due to stagnation of water in well; analysis supplied by city of Jamestown.
209-922-2	9/20/62	r196	S & G	--	.19	--	--	--	---	---	--	13	--	--	159	80	--	254	7.2	--	H_2S.
209-923-1	9/ 7/60	r25	S & G	--	.01	--	--	--	---	---	--	3.1	--	--	142	116	--	229	---	--	
-9	9/18/62	r30	S	--	.02	--	--	--	---	---	--	5.1	--	--	159	122	--	266	7.3	--	
-11	9/13/62	r203	G	--	.28	--	--	--	---	---	--	3.4	--	--	179	90	--	248	7.7	--	
209-924-1	8/11/60	r18	S & G	--	--	--	--	--	---	---	--	3.8	--	--	147	124	--	248	7.7	--	
-3	9/22/60	r64	S	--	.05	--	--	--	---	---	--	36	--	--	261	74	--	440	---	--	H_2S. Well may be obtaining some water from bedrock.
-5	8/13/62	30	S	--	.31	--	--	--	---	---	--	3.9	--	--	164	136	--	288	7.2	--	
210-912-1	11/22/60	79	B	--	--	--	--	--	---	---	--	4.0	--	--	98	76	--	171	---	--	
210-915-1	8/23/60	r240	S & G	--	--	--	--	--	---	---	--	3.6	--	--	113	84	--	194	7.6	--	H_2S.
-2	6/15/61	r138	S & G	--	.18	--	--	--	---	---	--	4.0	--	--	126	82	--	198	---	--	
-8	11/ 7/60	r80	S & G	--	--	--	--	--	---	---	--	20	--	--	291	220	--	468	---	--	
-11	11/ 8/60	r104	S & G	--	--	--	--	--	---	---	--	26	--	--	243	190	--	408	---	--	
211-901-1	8/26/61	46	S & G	--	.18	--	--	--	---	---	--	.8	--	--	189	80	--	320	---	--	H_2S.
211-915-1	4/ 3/62	358	G?	--	.54	--	--	--	---	---	--	14	--	--	269	66	--	402	---	--	A percentage of water may be contributed by bedrock.
-3	9/ 9/60	r356	S & G	--	--	--	--	--	---	---	--	12	--	--	176	70	--	287	---	--	
-14Sp	9/12/60	--	S & G	--	.03	--	--	--	---	---	--	5.3	--	--	172	139	--	283	---	--	
211-916-1	9/19/60	r95	B	--	.02	--	--	--	---	---	--	30	--	--	165	86	--	283	---	--	
211-926-1	9/22/60	r108	G	--	--	--	--	--	---	---	--	1.8	--	--	157	124	--	250	---	--	
-2	9/30/60	r28	S & G	--	--	--	--	--	---	---	--	1.4	--	--	190	162	--	311	---	--	
-4	8/21/52	r107	G	26	.33	35	8.2	4.8	.7	141	14	2.9	0	.3	153	121	6	249	7.7	10	
212-901-2	8/28/61	r184	G	--	.17	--	--	--	---	---	--	.6	--	--	152	100	--	238	---	--	H_2S.
-3	8/28/61	r130	S & G	--	.08	--	--	--	---	---	--	.0	--	--	152	90	--	250	---	--	
-4	8/28/61	r122	S & G	--	.06	--	--	--	---	---	--	.0	--	--	138	96	--	236	---	--	
212-902-1	8/12/60	r160	S & G	--	--	--	--	--	---	---	--	4.0	--	--	111	84	--	185	7.7	--	
-2	8/17/60	r124	S & G	--	--	--	--	--	---	---	--	4.8	--	--	164	93	--	218	8.6	--	H_2S.
212-906-1	6/ 2/58	r236	B	--	1.0	--	--	--	---	---	--	66	--	--	---	120	--	---	---	--	Analysis supplied by Ellington Elementary School.

Table 5.--Chemical analyses of ground water from the Jamestown area (Continued)

Well or spring number	Date of collection	Depth of well (feet)	Water-bearing material	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness (as $CaCO_3$)		Specific conductance (micromhos at 25°C)	pH	Color	Remarks
																Calcium, magnesium	Noncarbonate				
212-916-1	6/ 7/63	173	S & G	--	.15	--	--	--	---	---	--	34	--	--	154	119	--	330	7.4	--	H_2S.
213-901-1	8/10/61	r190	G	--	.10	--	--	--	---	---	--	6.0	--	--	150	95	--	236	---	--	H_2S.
213-902-1	8/ 4/61	r200	G	--	.31	--	--	--	---	---	--	1.6	--	--	119	92	--	190	---	--	H_2S.
-2	8/ 4/61	r156	G	--	.07	--	--	--	---	---	--	2.0	--	--	116	88	--	194	---	--	
-4	8/15/61	r104	G	--	.06	--	--	--	---	---	--	2.0	--	--	132	105	--	208	---	--	
213-903-6	9/ 5/61	42	S & G	--	.01	--	--	--	---	---	--	2.4	--	--	176	140	--	288	---	--	
213-904-1	8/10/61	r18	G	--	.02	--	--	--	---	---	--	1.0	--	--	94	78	--	159	---	--	
-2	8/10/61	r100	S & G	--	.01	--	--	--	---	---	--	1.6	--	--	128	106	--	206	---	--	
214-901-4	9/16/61	r18	S & G	--	.13	--	--	--	---	---	--	1.6	--	--	128	102	--	218	---	--	
214-902-1	8/24/61	r170	G	--	.13	--	--	--	---	---	--	.0	--	--	190	76	--	304	---	--	H_2S.
214-903-1	8/ 9/61	r314	G	--	.10	--	--	--	---	---	--	.6	--	--	129	84	--	190	---	--	
-7	4/ 2/62	r85	G	--	.25	--	--	--	---	---	--	1.0	--	--	213	154	--	330	---	--	H_2S.
-8	4/ 2/62	r362	G	--	.22	--	--	--	---	---	--	1.6	--	--	150	86	--	213	---	--	
214-930-2	8/19/52	r26	G	28	.14	39	13	4.9	.6	150	22	8.3	0	5.0	187	151	28	350	7.7	5	
215-916-2	10/26/49	r118	B	--	1.5	--	--	--	---	---	--	155.0	.45	.02	---	---	--	---	7.9	8	Alkalinity 125.0 ppm; nitrites (as N) 0.003 ppm; turbidity 30 ppm; odor hot and cold, 1 sweet aromatic; analysed by N.Y.S. Department of Health.
-3	7/20/56	r59	S & G	--	.18	--	--	--	---	---	--	4.4	--	--	112	---	--	---	8.0	0	Carbonate alkalinity 4.0 ppm; bicarbonate alkalinity 96.0 ppm; nitrites (as N) 0.001 ppm; turbidity, a trace; odor hot and cold, 2 aromatic; analysed by N.Y.S. Department of Health.
215-919-1	8/18/60	r105	G	--	--	--	--	--	---	---	--	5.2	--	--	125	92	--	217	7.5	--	
215-920-1	10/17/60	r104	G	--	--	--	--	--	---	---	--	2.4	--	--	146	124	--	245	---	--	
215-928-1	9/20/60	r153	S & G	--	.13	--	--	--	---	---	--	5.4	--	--	159	136	--	270	---	--	
216-917-1	10/28/60	40	S	--	--	--	--	--	---	---	--	26	--	--	175	116	--	318	---	--	Well may be obtaining some water from bedrock.
216-921-5	11/14/60	r120	B	--	--	--	--	--	---	---	--	15	--	--	123	62	--	230	---	--	H_2S.
217-905-2	7/ 6/61	r95	G	--	.18	--	--	--	---	---	--	5.6	--	--	142	96	--	238	---	--	
-4	8/ 9/61	r70	G	--	.10	--	--	--	---	---	--	4.0	--	--	159	117	--	264	---	--	
217-906-1	7/ 5/61	r63	G	--	.01	--	--	--	---	---	--	2.8	--	--	132	116	--	221	---	--	
-4	7/ 6/61	r36	G	--	.01	--	--	--	---	---	--	3.0	--	--	138	116	--	224	---	--	
217-918-1	10/15/60	r252	S	--	--	--	--	--	---	---	--	20	--	--	213	79	--	357	---	--	
217-919-2Sp	8/18/60	---	S	--	--	--	--	--	---	---	--	5.6	--	--	162	116	--	258	7.5	--	

Table 5.--Chemical analyses of ground water from the Jamestown area (Continued)

Well or spring number	Date of collection	Depth of well (feet)	Water-bearing material	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness (as $CaCO_3$)		Specific conductance (micromhos at 25°C)	pH	Color	Remarks
																Calcium, magnesium	Noncarbonate				
217-921-3	10/15/60	63	B	--	--	--	--	--	---	---	--	48	--	--	226	57	--	406	---	--	
217-922-1	10/27/60	r68	B	--	--	--	--	--	---	---	--	20	--	--	178	88	--	314	---	--	H_2S.
218-917-2	8/20/52	r110	B	8.9	.17	22	3.9	6.3	.9	84	17	5.0	.2	.9	103	71	2	175	7.4	5	
218-921-5	6/12/61	166	B	--	.51	--	--	--	---	---	--	52	--	--	339	62	--	543	---	--	
219-921-4	6/12/61	r28	S	--	.00	--	--	--	---	---	--	8.0	--	--	358	272	--	598	---	--	
-6	6/13/61	r22	S & G	--	.00	--	--	--	---	---	--	2.0	--	--	148	128	--	250	---	--	
220-919-2	9/ 6/60	r19	S & G	--	.23	--	--	--	---	---	--	6.0	--	--	168	142	--	280	---	--	
220-922-2	9/30/60	r24	G	--	.16	--	--	--	---	---	--	2.7	--	--	133	103	--	217	---	--	
-3	10/17/60	r54	G	--	--	--	--	--	---	---	--	7.4	--	--	124	97	--	212	---	--	
-5	10/27/60	r50	G	--	--	--	--	--	---	---	--	.4	--	--	154	136	--	265	---	--	H_2S.
220-923-1	9/14/60	r40	G	--	1.4	--	--	--	---	---	--	1.1	--	--	141	111	--	236	---	--	
-2	11/17/60	r90	B	--	--	--	--	--	---	---	--	44	--	--	292	124	--	513	---	--	
221-918-1	8/30/60	86	G	--	3.4	--	--	--	---	---	--	2.4	--	--	216	192	--	363	7.5	--	H_2S.
221-919-1	8/30/60	49	S & G	--	--	--	--	--	---	---	--	1.8	--	--	137	116	--	237	7.7	--	
-3	11/ 7/60	36	S & G	--	--	--	--	--	---	---	--	.6	--	--	176	166	--	307	---	--	
221-923-1	10/27/60	r120	B	--	--	--	--	--	---	---	--	35	--	--	203	59	--	356	---	--	

All constituents are reported in parts per million which is the ratio of the weight of chemical to the weight of solution. For instance, an analysis of iron reported as 1 ppm would indicate 1 pound of iron dissolved in a million pounds of solution.

No attempt was made to determine the bacteriological quality of the water. Therefore, the acceptability of the water from a chemical standpoint does not indicate that it is free of harmful organisms.

DISSOLVED SOLIDS

Dissolved solids is the residue obtained by evaporating a volume of water and drying the residue at 180° centigrade for 1 hour. For practical purposes, the dissolved solids, in ppm, may be taken as the total quantity of chemical constituents in the water except for those that were volatized or were changed during evaporation and heating.

The concentration of dissolved solids, based on 112 samples of ground water from the area, ranged from 90 to 4,440 ppm. The U.S. Public Health Service (1962) recommends a limit of 500 ppm dissolved solids for water used by common carriers engaged in interstate commerce. However, supplies with much higher dissolved solids may be used, if necessary, because the 500 ppm limit is based mainly on taste and potability of the water. The recommendations of the Public Health Service, although applicable only in interstate commerce, are generally followed where possible for all drinking water supplies.

The graphs in figure 40 show the concentration of dissolved solids according to three aquifer groups: (1) unconsolidated deposits less than 150 feet deep, (2) unconsolidated deposits more than 150 feet deep, and (3) bedrock. Of the samples from shallow unconsolidated deposits, more than 70 percent of the samples contained less than 201 ppm dissolved solids. Well 205-909-1, which contained 1,030 ppm dissolved solids, appears to be obtaining most of its water by upward movement of mineralized water from the underlying bedrock. The deeper unconsolidated deposits also yield water with a relatively low dissolved solids content.

Water from the bedrock tends to have a higher concentration of dissolved solids than water from the unconsolidated deposits. Fully 55 percent of the samples had a dissolved solids content of more than 200 ppm. Nearly one-fourth of the samples contained more than 500 ppm.

CHLORIDE

Chloride is one of the most common chemical constituents of ground water. The most frequent natural source of chloride in ground water is sodium chloride, or common salt. Chloride is objectionable in water because in concentrations above 250 ppm the water will taste salty to many people. For this reason the U.S. Public Health Service recommends 250 ppm as the upper limit for drinking water. Water from 119 wells and springs in the area were analysed for chloride content. The concentration of chloride

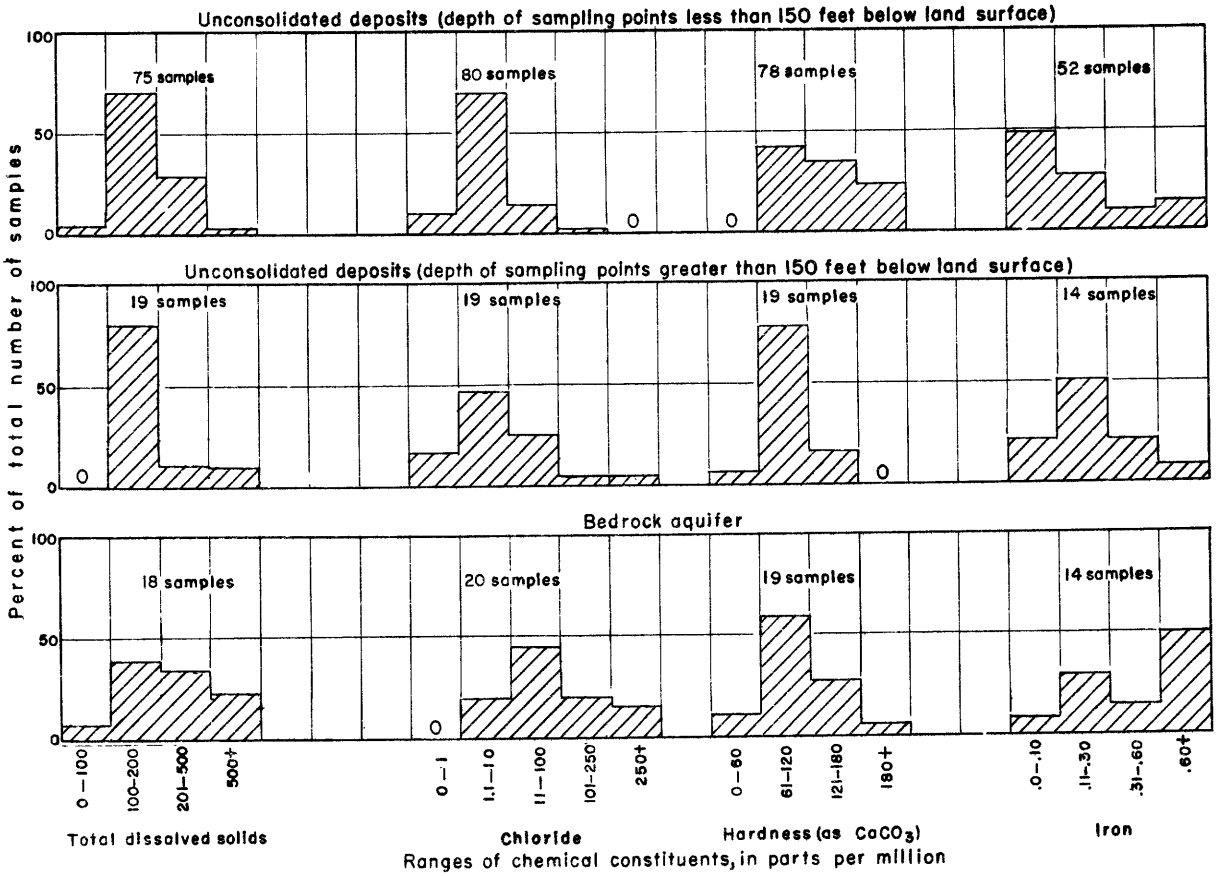


Figure 40.--Percentage of chemical constituents of ground water from three different aquifer groups.

ranged from 0.0 to 2,420 ppm. Figure 41 shows the distribution of the sampling points for chloride and the range of concentration at each point. The type of aquifer and depth of well are also shown. Chloride concentrations above 10 ppm, when occurring in shallow water-table aquifers, often indicate pollution. This pollution is probably caused largely by either human wastes discharged to the ground through cesspools and septic tanks or from salt that is spread on streets and highways during the winter to melt ice.

A definite relationship exists between the chloride concentration, depth, and type of aquifer. Figure 40 shows the relationship of various concentrations of chloride to aquifer type and depth.

Eighty percent of the water samples from unconsolidated deposits at depths of less than 150 feet below land surface contained less than 10 ppm chloride. The somewhat high chloride content from wells 203-913-4, 205-909-1, and 207-917-2 seems to indicate that much of the water is derived from upward discharge of mineralized water from the underlying bedrock. None of the samples contained more than 250 ppm chloride. Water from wells in unconsolidated material more than 150 feet deep contains a somewhat higher chloride content than water from shallow deposits.

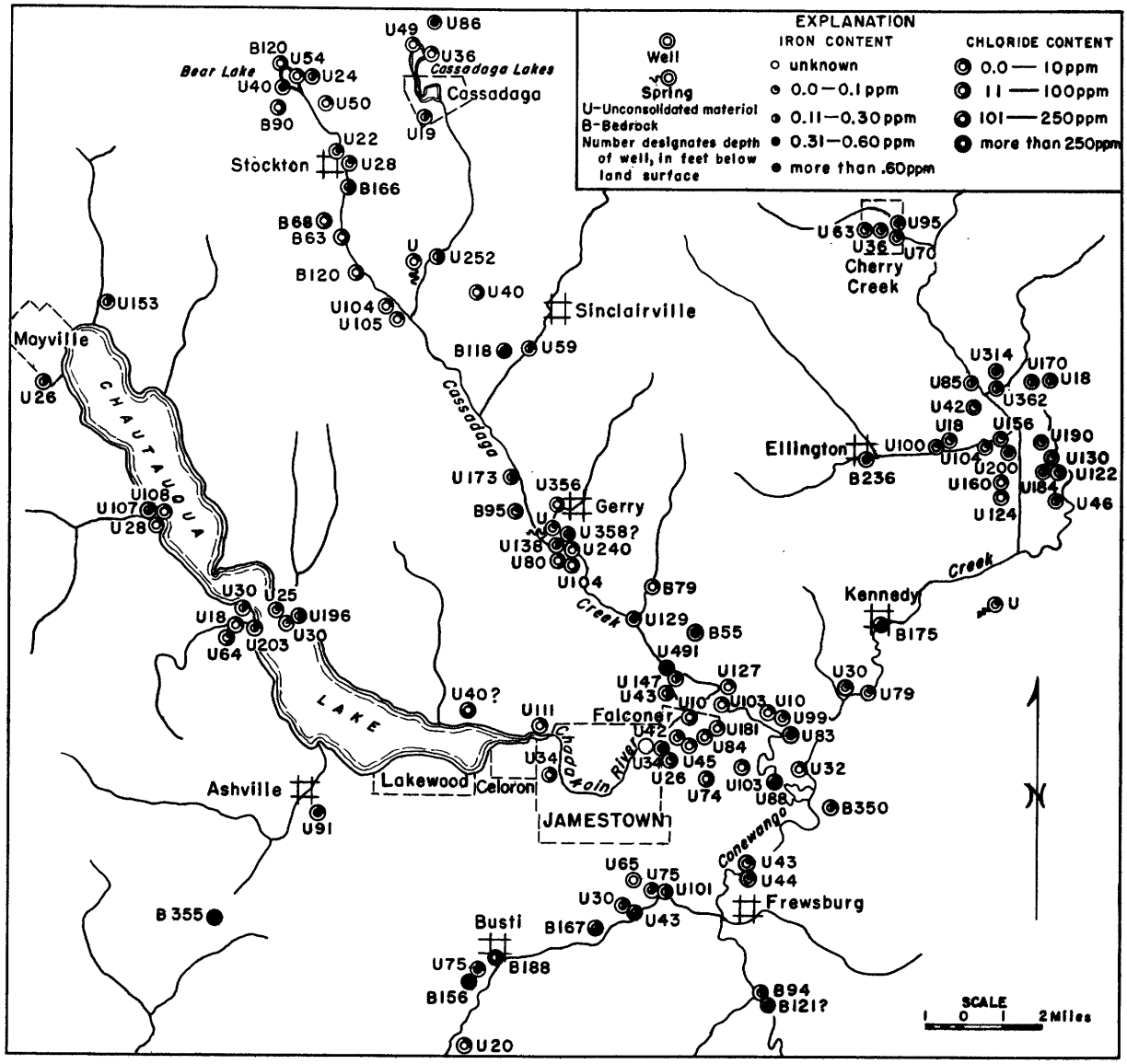


Figure 41.--Location of sampling points, range of chloride and iron concentrations, type of deposits, and depth of wells.

The samples of water from bedrock show that 35 percent of the wells sampled contained water with more than 100 ppm chloride. Some 45 percent of the wells had a chloride content between 10 and 100 ppm. In 15 percent of the wells the water contained more than 250 ppm chloride.

The relatively highly mineralized water in the area is believed to be moving upward from deep layers in the bedrock. There are rock salt beds underlying the western and southern portion of the area at depths ranging from 1,500 feet below mean sea level in the north to more than 2,000 feet below mean sea level in the south (Kreidler, 1957). These salt deposits were penetrated by deep test wells drilled for oil and natural gas. Several of the test wells also reportedly penetrated zones containing very salty

water at much shallower depths than the rock salt. The mineralized water could result from deep circulation of fresh ground water down to the salt beds. Most of the upward movement may be along natural breaks in the rocks. However, many old test wells exist, especially in the southern portion of the area, and several of them have not been adequately plugged. Therefore, it is possible that some of the water is moving up through abandoned oil and gas test wells.

It should be pointed out that all the analyses of water from bedrock are for wells at the lower altitudes in the valley areas. The bedrock wells in the uplands would not be expected to have such a high chloride content because fresh water is moving downward from the uplands in these areas toward the valleys.

HARDNESS

Hardness may be called the soap-consuming power of water. It is due mainly to the presence of calcium, magnesium, and other alkaline earth metals which form insoluble compounds with soap. For convenience, hardness is usually reported in ppm as total hardness equivalent to calcium carbonate.

Hardness is undesirable in water because the reaction with soap causes the formation of a scum on the water, and a greater quantity of soap must be used to produce a lather. High hardness also causes the formation of scale on the inside of boilers and pipes. The relative hardness of water is usually described as follows: 0 to 60 ppm, soft; 61 to 120 ppm, moderately hard; 121 to 180 ppm, hard; and greater than 180 ppm, very hard.

Hardness of water sampled in the Jamestown area ranged from 46 to 1,090 ppm, based on 116 samples. As shown in figure 40, the water from the shallow unconsolidated deposits tended to be harder than that from the deep unconsolidated deposits. In fact, nearly 60 percent of the ground water in this group would be termed hard.

Interestingly, the water from the bedrock also tends to be slightly harder than that from the deep unconsolidated deposits. This may seem to be illogical because the water in the deep unconsolidated deposits should be somewhere between the other two aquifer groups in hardness. However, the explanation for this may be that part of the water is naturally softened. This would occur by having the calcium and magnesium exchanged for sodium, which forms soluble compounds, as the water moves through the thick deposits of clay and silt.

IRON

Iron in excess of about 0.3 ppm is likely to cause staining of porcelain fixtures. People with a sensitive taste may also detect the presence of iron at this concentration. For these reasons, the U.S. Public Health Service recommends that water containing more than 0.3 ppm of iron should not be used where more suitable supplies are available.

Determinations for iron were made on 80 samples of ground water, and concentrations were found to range from 0.01 to 3.4 ppm. Location of sampling points, range of concentrations, type of deposits, and depth of wells are shown in figure 41. The remarks columns of tables 5 and 6 also contain reports of iron by well owners.

Figure 40 shows the relative concentrations of iron in the three aquifer groups. Fully 75 percent of the wells in the shallow unconsolidated deposits contain less than 0.31 ppm of iron. The water in the deep unconsolidated deposits contains only slightly more iron and about 70 percent of these samples show less than 0.31 ppm.

About 64 percent of the water samples obtained from the bedrock aquifer contain more than 0.3 ppm of iron. However, part of this iron may not reflect the natural quality of the ground water outside the well. Because many of the bedrock wells contain hydrogen sulfide gas, the water tends to be acidic. (See below.) This makes it possible for the water to dissolve some of the iron from the well casing and plumbing which may give an erroneously high iron content for the ground water in the bedrock.

HYDROGEN SULFIDE (H_2S)

The gas hydrogen sulfide (H_2S) is quite widespread in the ground water throughout the Jamestown area. It gives the water a characteristic odor of "rotten eggs." The principal problems caused by hydrogen sulfide are the odor and the fact that it makes the water acidic. As mentioned before, this causes the water to be quite corrosive which may lead to iron staining and damage to plumbing. The gas is also toxic but is usually not present in large enough quantities to be harmful. Aeration will allow the gas to escape from the water and make it more palatable.

No quantitative determinations of hydrogen sulfide were made. However, it was noted in several water supplies and reported by many well owners. Concentrations of as little as 1 ppm is enough to cause a strong odor. The remarks columns of tables 5 and 6 note any occurrence of hydrogen sulfide. Homeowners often report the presence of hydrogen sulfide as "sulfur water."

The hydrogen sulfide tends to occur in the bedrock aquifer or in unconsolidated aquifers confined under silt and clay. It may be formed from the reduction of sulfate by bacteria in the presence of natural gas (CH_4) (Hem, 1959, p. 223) or by the oxidation of iron pyrite (FeS_2) in the bedrock.

NATURAL GAS (METHANE)

Natural gas (methane) is odorless and colorless but very flammable. This latter property makes it undesirable in water supplies. The accumulation of natural gas in cellars and plumbing systems is a potential fire hazard. Its presence in ground water is noted in the remarks columns of tables 5 and 6.

The occurrence of natural gas is quite widespread throughout the Jamestown area. Several commercial and domestic gas wells have been developed in the area and some of the domestic wells have been included in table 6. Most occurrences of the gas in water wells are in small quantities, but large quantities were noted in wells 201-917-6, 202-916-4, and 205-908-1.

Natural gas may occur in any well which ends in bedrock or in unconsolidated deposits overlain by fine-grained material. Depth is not of primary importance because pockets of gas may occur in the bedrock at nearly any depth (Newland and Hartnagel, 1939). However, there is definitely a greater chance of finding gas in deeper wells, especially in the southern half of the area. Often when gas is found in drilling a water well, the quantity of gas will decline rapidly if allowed to escape. Well 205-909-3 is an outstanding example of this. When drilled, a gas pocket was tapped and the well reportedly produced 9.5 million cubic feet per day. The gas flow declined rapidly and after several days was unmeasurable.

Most of the gas occurs naturally in the bedrock and is continually moving up from deeper depths. It is possible that many of the shallow deposits are partially due to leakage from old gas test wells, or that the upward movement of the gas has been facilitated by these abandoned wells.

SPECIFIC CONDUCTANCE

Specific conductance is a measure of the ability of the water to conduct electricity and indirectly a measure of the mineral content. The more heavily mineralized a water sample, the more readily it will conduct electricity. The specific conductance was determined on most of the water samples in table 5 to provide a clue to the concentration of chemical constituents.

HYDROGEN-ION CONCENTRATION (pH)

The pH of a solution is defined as the negative logarithm of the hydrogen-ion concentration. It is used to express the acidity and alkalinity of a solution. A pH of 7 is considered neutral, and the solution would be neither acidic nor alkaline. A solution with a lower pH than this would be acidic, and that with a higher pH would be alkaline.

The pH is very important because a water with a low pH (acidic) tends to be corrosive, and water with a high pH (basic or alkaline), tends to cause deposition of mineral matter from solution such as calcium carbonate. In general, this also means that water with a low pH can dissolve and contain more chemical constituents than water with a high pH.

The analyses listed in table 5 have a pH range of from 6.9 to 8.6. This would seem to indicate that most of the ground water in the area is alkaline. However, this may be misleading because all of the samples were analysed some weeks after they were collected and it is quite probable that the pH of the samples changed. For this reason, the pH readings in table 5 probably give only a rough indication of the actual pH of the water in the ground. It is to be expected that some of the ground water in the Jamestown area would

actually be acidic and, therefore, corrosive in nature. This would undoubtedly be true of those waters derived from the deeper unconsolidated deposits, and from the bedrock, which contain hydrogen sulfide gas.

NITRATE

Thirteen analyses for nitrate are shown in table 5. Nitrate may be an important chemical constituent of ground water in some areas. In most natural waters it is present in amounts of less than 1.0 ppm. Its presence in concentrations greater than 5.0 ppm is often an indication of pollution. Also, water containing more than 45 ppm nitrate is believed to be toxic to infants. Therefore, the U.S. Public Health Service recommends that this be the upper limit of concentration in a water supply used for human consumption.

Wells 204-909-1 and -2, of the Frewsburg supply, contained nitrate concentrations of 20 and 9.5 ppm, respectively. The water from well 207-906-6, at the Poland Center test site, contained a nitrate concentration of 17 ppm. Because all three of these wells are located adjacent to Conewango Creek, it is possible that the high nitrate is derived from creek water that infiltrates into these deposits.

OTHER CONSTITUENTS

Many other constituents occur in the water in the area, but not in great enough quantities to limit its use for human consumption.

Sulfate analyses are recorded for 13 wells in the area and concentrations range from 1.5 to 65 ppm. However, the 65 ppm in water from well 206-915-4 is probably due to pollution. The U.S. Public Health Service recommends an upper limit of 250 ppm sulfate in drinking water. This concentration would probably not be exceeded in the natural ground water in the area except for deeper wells in the bedrock.

Fluoride analyses on 13 wells showed concentrations from 0 to 0.5 ppm. The U.S. Public Health Service recommends a limit of 1.5 ppm. It is doubtful that any concentrations exceeding this amount would be found in the area except possibly in water derived from extremely deep bedrock wells.

Several other constituents such as silica, sodium, potassium, and bicarbonate are reported for a few wells. However, the concentrations shown tend to be low, and it is doubtful if any one of these constituents alone would cause problems with respect to the use of the water.

POLLUTION

INDUSTRIAL

The ground water from water-table wells and most shallow wells along the Chadakoin River probably contains many chemical constituents not reported in table 5.

A survey of the Chadakoin River, conducted by the New York State Department of Health (no date), reported toxic concentrations of cyanide, lead, zinc, and copper in the river water. These chemicals were reported to be discharged into the river by various industries along the banks. Many of the toxic chemicals are undoubtedly also finding their way into the ground-water body because several of the large industrial wells induce recharge from the river, especially at low flows. The concentration of some of these substances in the river, such as cyanide, far exceeds the limit set by the U.S. Public Health Service for human consumption. Therefore, most of the shallow ground water along the river must be regarded as unsafe or potentially unsafe for domestic use. However, the acceptability of the water for industrial use is not dependent on the same criteria and must be determined by individual industries. Most of the industries now find the water acceptable without treatment.

DOMESTIC WASTES

Pollution with domestic (human) wastes is both chemical and bacteriological. No specific analyses or studies were made to try to locate points of such pollution. However, the presence of an above normal concentration of chlorides and nitrates in shallow wells often indicates a polluted water supply. This pollution is most likely to occur in areas where septic tanks are found in close proximity. The concentrated construction of dwellings in areas without public water supplies and sanitary sewers, such as around Chautauqua Lake and in the smaller hamlets, always presents the possibility of ground-water pollution. A shallow aquifer is the most likely to be polluted, although almost any aquifer may be affected under certain conditions. With the intensive development of suburban areas without sewers, this problem will probably increase and have an important effect on the utilization of water supplies in many parts of the area.

TEMPERATURE

Water temperature was measured for several wells in the area and is reported in table 6. The water temperatures were generally found to range within a few degrees of the mean annual air temperature of about 49°F.

The ground-water temperatures are influenced by the air temperature. The range in water temperature is greatest within the upper few feet of the land surface. However, as the depth below the land surface increases, the effect of short-duration changes in the air temperature becomes less noticeable due to the insulating effect of the subsurface material. Below a depth of 30 to 60 feet there is very little range in the ground-water temperature and it remains at an almost constant temperature of about 3°F above the mean annual air temperature (Heath, 1963).

Some exceptions to this occur in areas where there is abundant infiltration of water from streams, as in well 210-912-2 (fig. 23). In these cases the ground water will have a larger range in temperature. Also, water from very deep wells may have a slightly higher temperature than water from shallow wells because of the increasing temperature of the earth with depth. This increase in temperature is about 1°F for every additional 100 feet of depth.

SUMMARY OF WATER QUALITY

Based upon the chemical analyses, reports of well owners, and the geology, several general conclusions may be reached about the chemical quality of ground water in the Jamestown area.

UNCONSOLIDATED DEPOSITS

Water in the unconsolidated deposits less than 150 feet below land surface is usually satisfactory for most purposes. The water tends to be somewhat hard but very low in chloride, iron, and dissolved solids. The only important exception to this is a small area east of Jamestown (area B in figure 42) and the area along the Chadakoin River in the Jamestown-Falconer area (area C in figure 42). Ground water in area C may also be chemically polluted.

The water contained in unconsolidated deposits at depths greater than 150 feet below land surface is also usually satisfactory for most uses. Most of the water in these deposits is softer but higher in iron than the water in the shallower deposits. However, the concentration of chloride and dissolved solids generally increases with depth, and some of the deeper deposits may contain mineralized water.

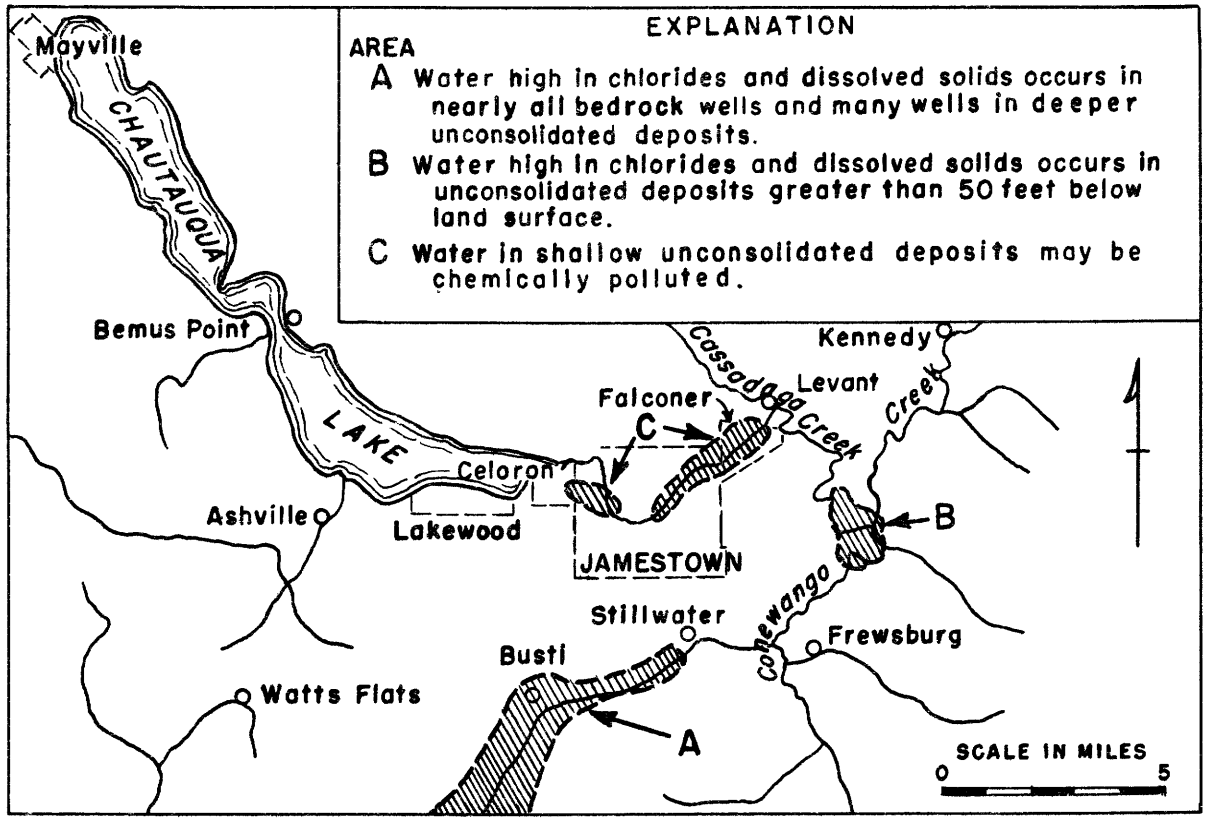


Figure 42.--Areas of water-quality problems.

BEDROCK

Wells in bedrock in the uplands generally yield water of good quality. Wells ending in bedrock in the valley areas are more likely to yield water that is of poor quality. Nearly 50 percent of the analyses of water from bedrock wells show that the water is objectionable because of either high chloride, dissolved solids, or iron content. Water from many bedrock wells also contains H_2S and natural gas. However, it must be pointed out again that most of the data collected on bedrock wells represents wells in the valley areas which bottom at much lower atltitudes than those in the uplands.

The deeper a bedrock well is drilled in the valley areas, the greater the risk of tapping water which is high in both chloride and dissolved solids. The possibility of obtaining water high in H_2S and natural gas also increases with depth. Nearly all bedrock wells in the Stillwater Creek valley yield water high in chloride content (area A in figure 42), even at shallow depths.

SUMMARY

The Jamestown area is in extreme southwestern New York. Altitudes in the region range from about 1,200 to 2,100 feet. The area consists of three broad flat-bottomed valleys lying between rolling uplands. The drainage of the area is southward into the Allegheny River system, but immediately to the north an escarpment dips away to Lake Erie from an altitude of 1,500 to about 600 feet.

The area has a humid-continental climate; the mean annual air temperature is about 49°F and the average annual precipitation is about 42 inches. Approximately one-half of the precipitation is used to meet evapotranspiration demands; the remainder is available for ground-water recharge and overland runoff.

The bedrock underlying most of the area consists of Upper Devonian shale, siltstone, and sandstone. The beds generally dip to the south at approximately 50 feet per mile. Except for the extreme southeast corner, the area has been glaciated and is covered by glacial material. The three large valleys are filled with glacial outwash and lake-laid deposits in places to depths of more than 600 feet. Lake-laid deposits predominate. Large terminal moraines are found in the northern part of the area and in parts of the valleys.

Although ground water is found everywhere in the area, yields of wells in bedrock and till in the uplands are usually less than 10 gpm and are only satisfactory for domestic and farm supplies. The most productive water-bearing deposits are found in the unconsolidated deposits in the valleys and may be divided into two broad groups: (1) glacial outwash of sand and gravel which occurs as layers either overlying or confined in the silt and clay in the valleys, and (2) deltaic deposits of sand and gravel formed by tributary streams entering the larger valleys from the uplands. The deltaic deposits have rather large volumes and interfinger with the silt and clay.

The most important water-bearing deposit in the area is the Jamestown aquifer which supplies the city of Jamestown. The aquifer underlies much of the Cassadaga Creek valley and extends eastward into part of the Conewango Creek valley. It consists of a glacial deposit of sand and gravel whose average thickness is about 20 feet, and it lies below a body of silt and clay as much as 140 feet thick. The depth to the top of the aquifer is least in the Conewango Creek valley and increases up the Cassadaga Creek valley.

The Jamestown aquifer is hydraulically connected to the lower parts of several of the delta deposits in the Cassadaga Creek valley. Before pumping from the aquifer began, water was recharged to the aquifer through these delta deposits and discharged, by slow upward percolation, through the silt

and clay confining bed in the central part of the valley. At that time there was a gradient in the aquifer from north to southeast, and the hydraulic head was above land surface.

The city of Jamestown now (1965) pumps about 6 mgd from a well field in the Cassadaga Creek valley northeast of the city. This pumpage has established a gradient in the aquifer toward the well field from both north and south. The hydraulic head in the aquifer is now depressed below the land surface except in the northern reaches of the Cassadaga Creek valley and in certain other areas during the spring of the year. About 90 percent of the water pumped by the city is derived from that part of the aquifer north of the well field. Water in this part of the aquifer is recharged through the delta deposits. This recharge is derived both from precipitation on the deltas and from infiltration of water from the streams crossing them. When recharge to the aquifer from these sources is inadequate, water is drawn from storage in the deltas.

The maximum perennial yield of the Jamestown well field depends on the amount of water stored in the delta deposits during the summer and the gradient available to deliver this water to the well field. On the basis of records of water levels in the aquifer and of pumpage, the maximum perennial yield of the well field without dewatering the aquifer was determined to be about 10 mgd. The limiting factor in the yield of the well field is the amount of water in storage which can be derived from the deltas during the summer season. The maximum perennial yield might be increased by constructing surface reservoirs on the tributary streams to store excess streamflow during the spring and release it to recharge the deltas during the summer. Also, additional water may be available from the northern part of the aquifer if additional supply wells are constructed in the areas little affected by the present field.

Another important aquifer is located at the center of the Conewango Creek valley near Poland Center. The Poland Center aquifer consists of a deposit of sand and gravel ranging in known thickness from 5 to 36 feet and overlain by about 10 to 80 feet of silt and clay. The permeability of the deposit was determined to be about 17,000 gpd per foot. The aquifer is hydraulically connected to the Conewango Creek. At present more information is needed to define the extent, character, and recharge capabilities of the aquifer. However, it appears capable of yielding a few million gallons per day.

The other valleys in the Jamestown area are not known to include large aquifers comparable to the Jamestown aquifer. Therefore, most of the ground-water development has been directly in delta deposits or small glacial outwash deposits. Because many of the delta deposits have both large volumes and readily available recharge, they are capable of yielding moderate quantities of water.

The quality of the ground water found in the shallower unconsolidated deposits is generally satisfactory for most uses. The water tends to be hard but low in chloride, dissolved solids, and iron. Some of the deeper unconsolidated deposits may contain water of poor quality because the concentration of chloride and dissolved solids increases with depth. Water derived from the bedrock aquifer is usually higher in chloride, dissolved

solids, and iron than that in the unconsolidated deposits. The quality of ground water in the bedrock aquifer deteriorates rapidly with increasing depth and appears to be due to highly mineralized water migrating upward from depth, both by movement along fractures in the rock and via old test wells. Natural gas and hydrogen sulfide are common in the bedrock aquifer.

At present (1965) about 7.5 mgd of ground water is pumped in the Jamestown area for public water supplies. Another 1.5 mgd is pumped for industrial use and 1.5 mgd is derived from private wells for domestic and farm purposes.

More water may be obtained from ground-water sources in the future. Larger yields may be obtained from the Jamestown aquifer, and the Poland Center aquifer is a promising source of large supplies. Some additional development is also possible in many of the delta deposits and the low-lying deposits of sand and gravel in the valley areas.

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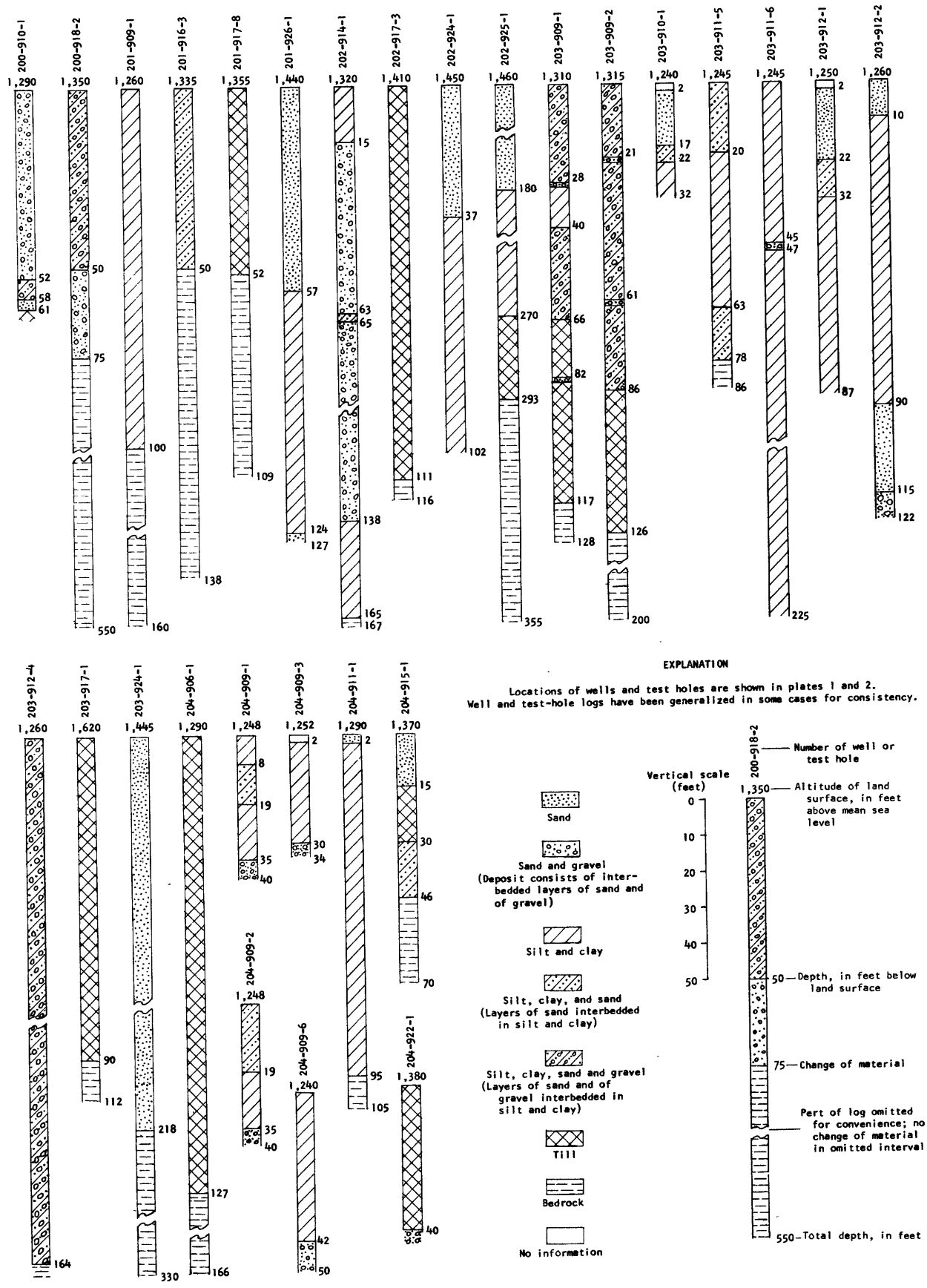

Figure 43.--Logs of wells and test holes.

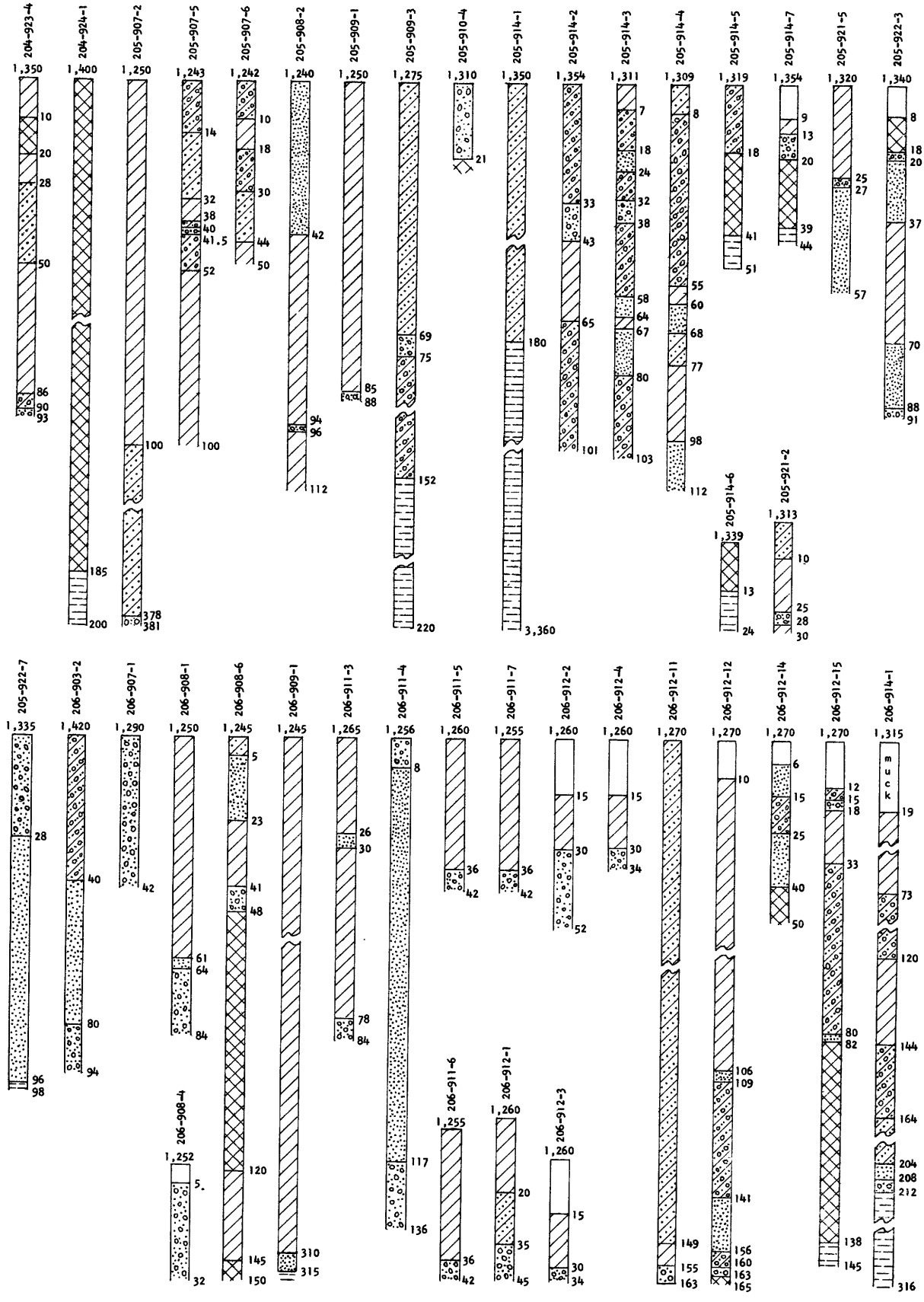

Figure 43.--Logs of wells and test holes (continued).

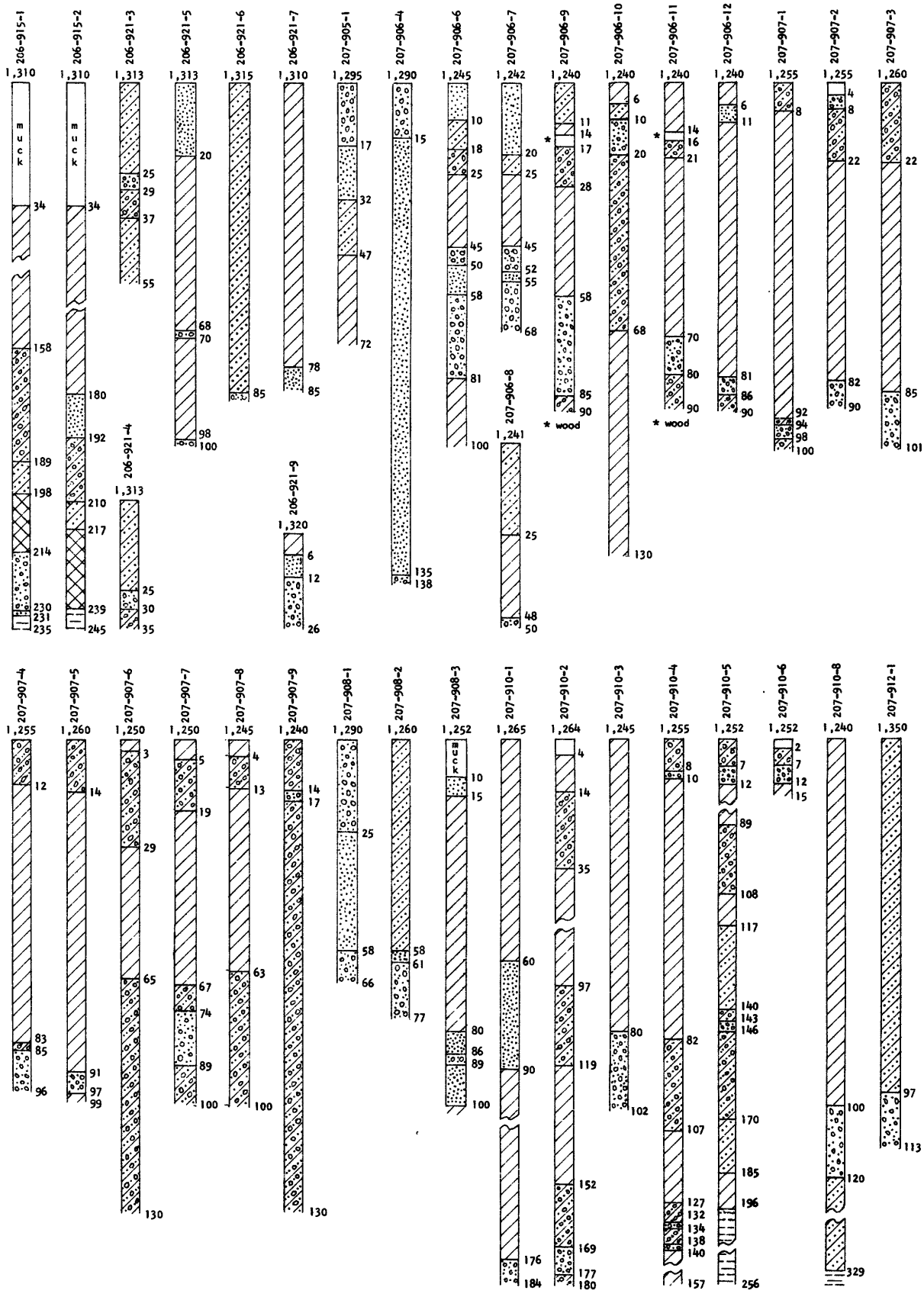

Figure 43.--Logs of wells and test holes (continued).

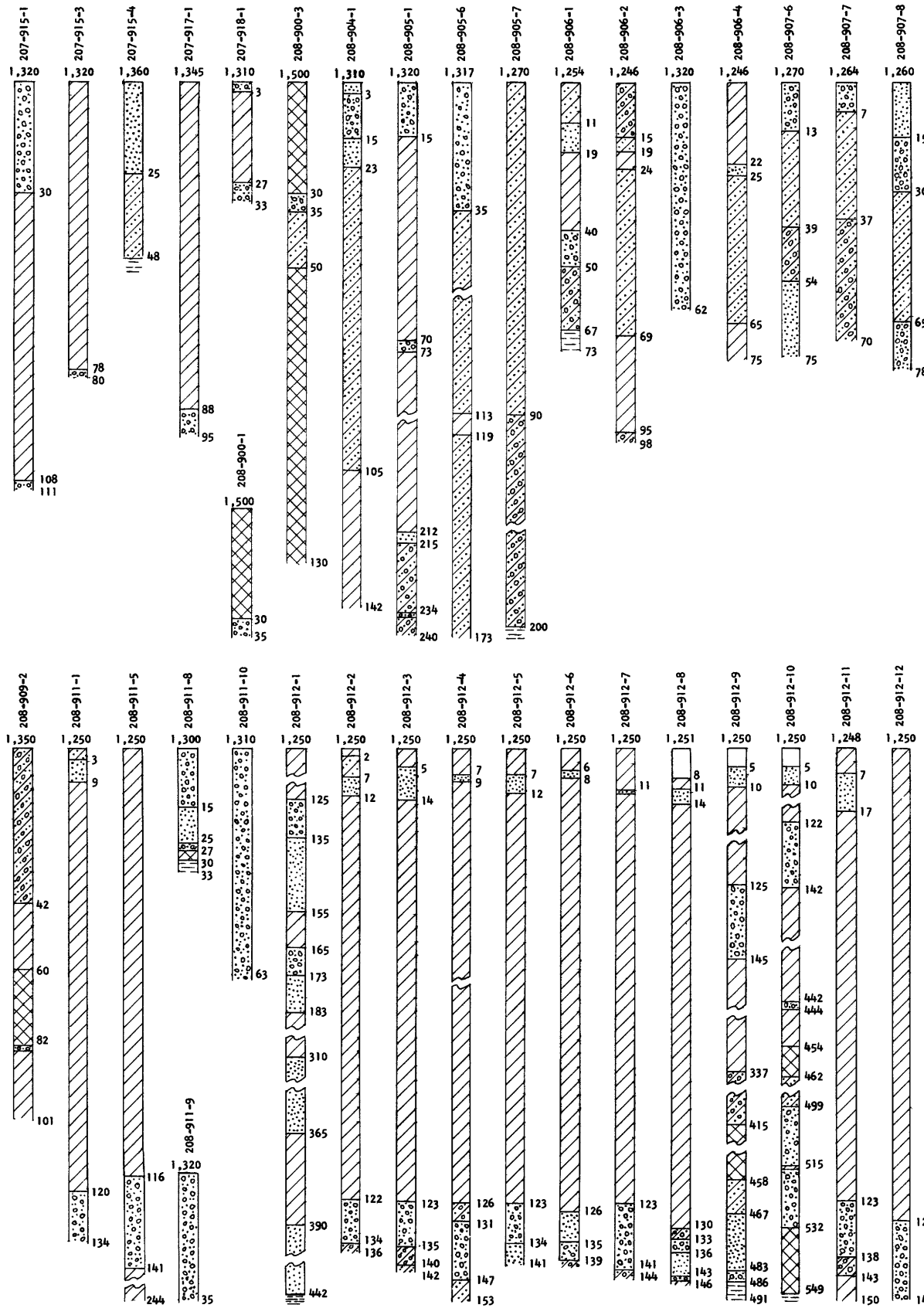

Figure 43.--Logs of wells and test holes (continued).

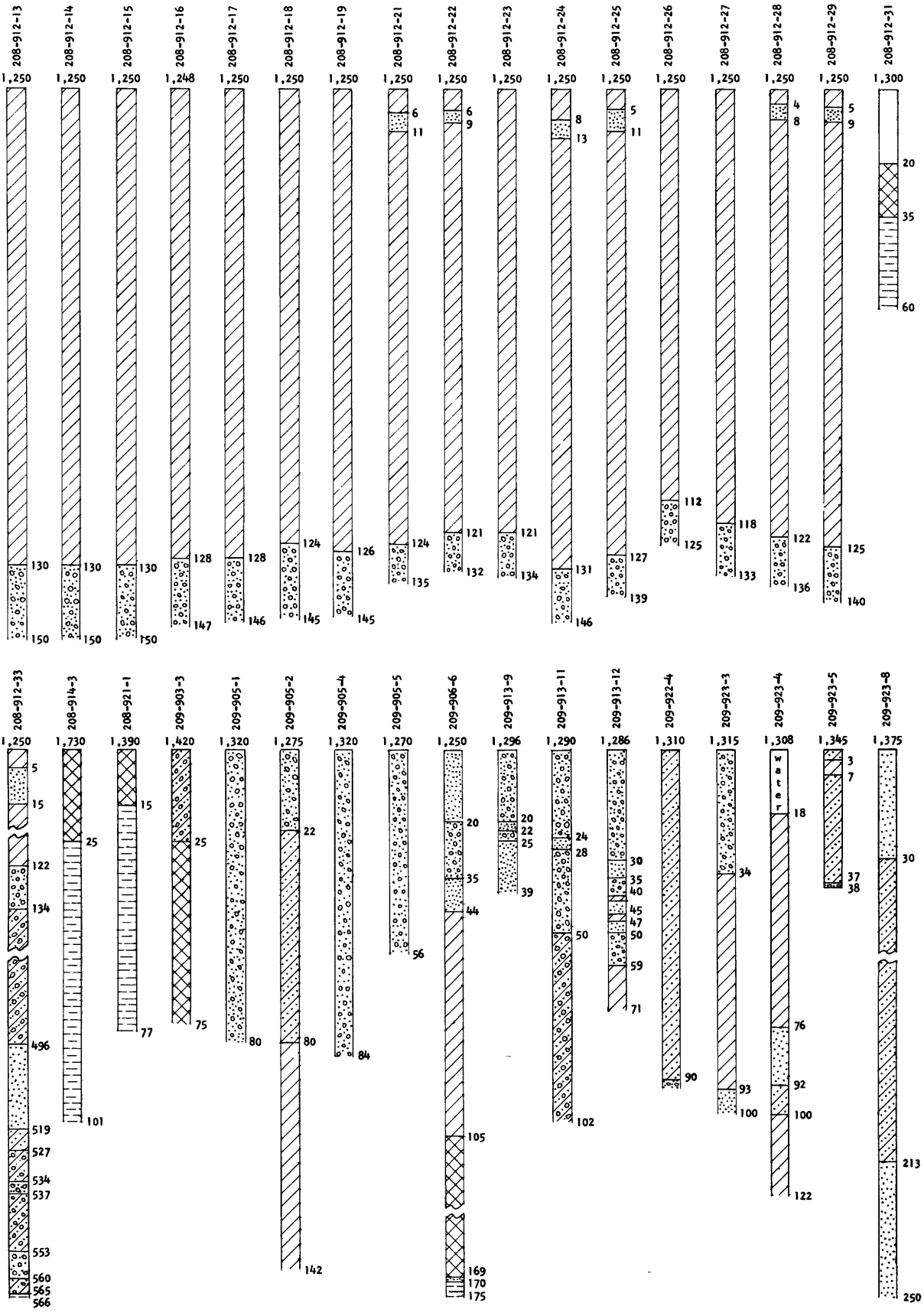

Figure 43.--Logs of wells and test holes (continued).

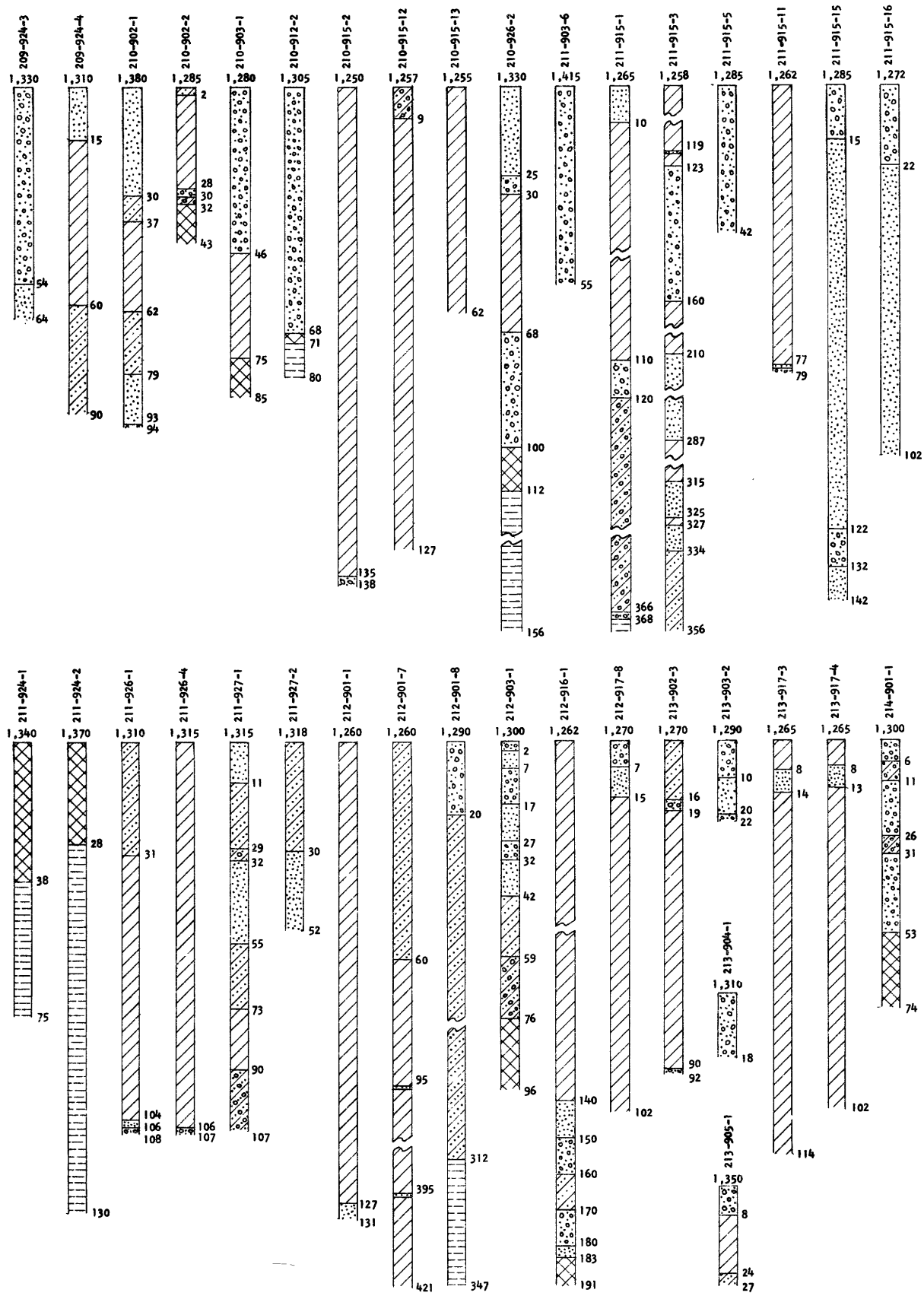

Figure 43.--Logs of wells and test holes (continued).

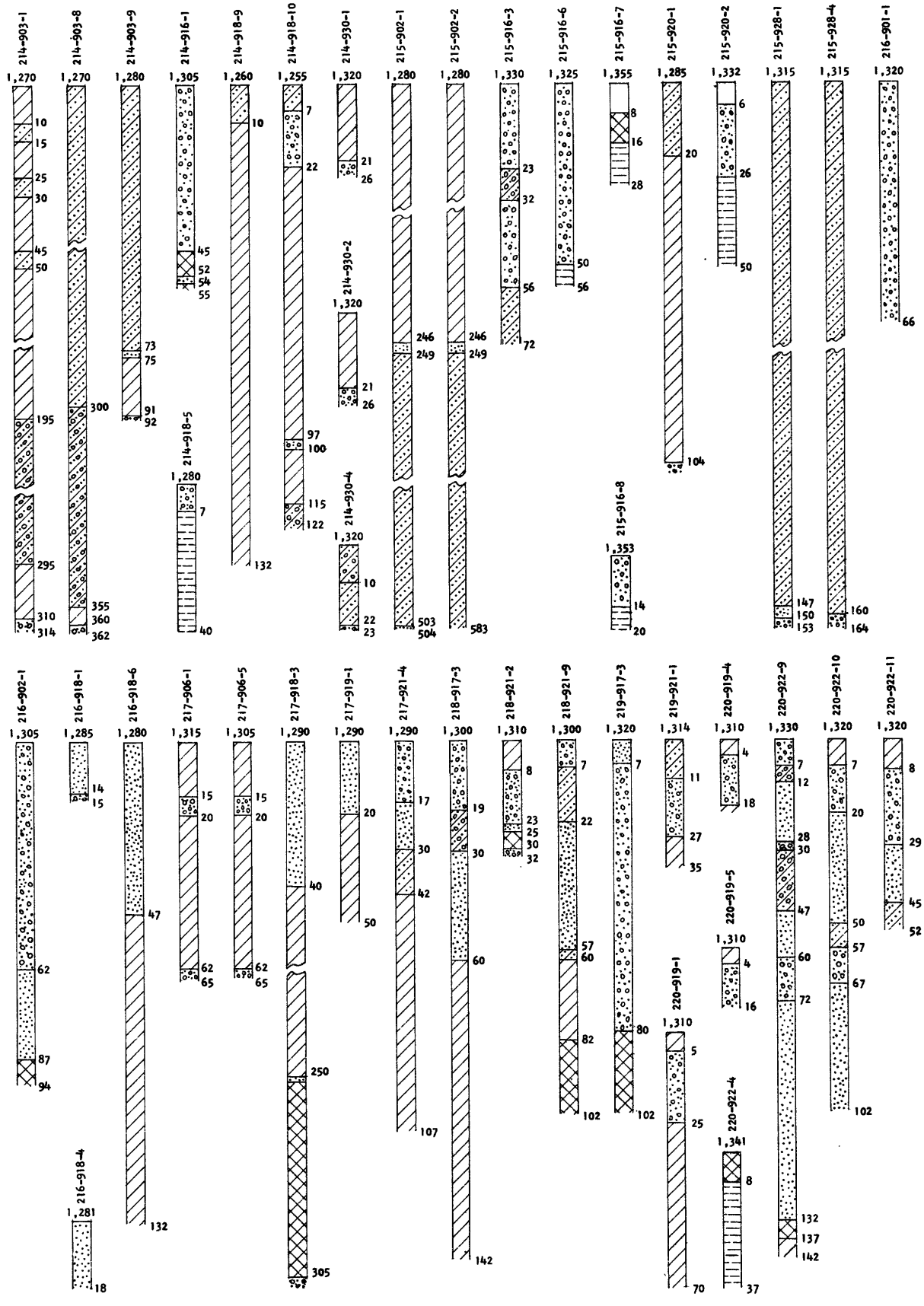

Figure 43.--Logs of wells and test holes (continued).

Table 6.--Records of selected wells and test holes in the Jamestown area

Well number: See "Well-Numbering System" in text for explanation.

Year completed: a - about
b - before

Type of well: Aug - augered
Drl - drilled
Dug - dug
Drv - driven
Jet - jetted

Depth of well: All depths below land surface.
r - reported
? - questionable
all others measured

Diameter of wells: Diameters of dug wells are approximate.
Where two or more sizes of casing were used, the top and bottom diameters are given.

Depth to bedrock: All depths below land surface.
a - about
r - reported
all others measured

Water-bearing meterial: sand, gravel, clay, silt, and till - Unconsolidated deposits of Pleistocene age. Gravel almost invariably occurs in layers interbedded with layers of sand. Wells are usually bottomed in the most permeable zone in any water-bearing deposit. Therefore, the report of gravel alone actually reflects only the zone in which the well is bottomed, and the entire water-bearing deposit should be considered as consisting of sand and gravel.
bedrock (interbedded shale and siltstone with some sandstone) - Consolidated rock of Devonian age.

Altitude above sea level: b - altitude of land surface measured by barometric altimeter.
s - altitude of land surface measured by surveying instruments.
? - questionable
all others estimated from topographic maps to nearest 5 feet.

Water level below land surface: All water levels are below land surface except those preceded by a plus (+) sign which are above land surface.
e - estimated
flows - water flows above land surface
r - reported
all others measured by U.S.G.S. personnel
F - series of water-level measurements on file in U.S.G.S. office, Albany, N. Y.
p - pumping effects probable

Method of lift: Pump
Dw - deep well
Sw - shallow well
A shallow well pump will not lift water if the water level declines more than about 25 feet below the altitude of the suction pipe entering the pump.
Power
M - manually operated
I - operated by internal combustion engine
all others electrically operated

Estimated pumpage: gpd - gallons per day
s - summer
w - winter
Daily pumpage either supplied by owners or computed from the following values:
each person - 50 gpd
each milk cow - 20 gpd

Use: A - abandoned
C - commercial
D - domestic
De - destroyed
F - farm
G - gas or oil
I - industrial
In - institutional
Ir - irrigation
O - observation
PS - public supply
T - test
U - unused

Remarks: anal - chemical analysis in this report
(b) - bailed
csg - depth of casing below land surface
dd - drawdown
flow - natural flow
gas - well yields flammable gas (natural gas or methane)
gpd - gallons per day
gpm - gallons per minute
H_2S - noticeable odor of hydrogen sulfide ("sulfur water")
inadequate - yield reported inadequate by owner
iron - water contains a relatively high concentration of iron, and stains porcelain fixtures
log - graphical log in this report
LS - land surface
ppm - parts per million
pt - pumping test data on file, U.S.G.S. office, Albany, N. Y.
(r) - reported information
salty - water is salty to taste
temp - temperature, in degrees Fahrenheit, measured by U.S.G.S.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing material	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
200-909-1	G. Coons	1960	Drv	r10	1 1/4	--	Sand and gravel	1,250	r5	--	Sw M	--	F	Iron; finished with screened drive point; another driven well on property supplies the house.
200-910-1	U.S. Geological Survey	1961	Aug	61	3	--	Sand	1,290	24.7	7/13/61	--	--	T	Log.
-2	L. Johnson	--	Drv	17	1 1/4	--	Sand and gravel	1,250	12.4	8/17/61	--	--	A	Inadequate; finished with screened drive point.
-3	J. Wheelhouse	--	Drl	r70	4	--	Gravel	1,290	r20	--	Dw	100	D	
200-917-1	D. Johnson	1958	Drl	r70	7	--	Sand and gravel	1,385	--	--	Dw	200	D	Deepened from 55 to 70 ft below LS in 1958.
-2	W. Prince	1956	Drl	r80	5	--	Bedrock	1,400	--	--	Sw	100	D	
-3	L. Eckstrom	--	Dug	20	20	--	Sand	1,370	8.8	6/ 8/61	Sw	250	D	Anal.
200-918-1	P. Peereboom	--	Drl	r100	6	r20	Bedrock	1,380	11.6	6/ 9/61	--	--	A	Gas; salty; well originally reported to be 100 ft deep, now partially plugged 14 ft below LS.
-2	J. Evinczik	1959	Drl	r550	8	r75	do.	1,350	--	--	--	--	G	Log; gas; well also yields oil; driller reports first water was found in bedrock.
200-923-1	G. Tichy	a1936	Drl	r35	5	--	Sand and gravel?	1,570	--	--	Sw	300	D	Water-bearing material may be sand and gravel lense in till.
200-924-1	D. Lundsten	a1936	Drl	r84	6	--	Bedrock?	1,590	r21	11/ /61	Dw	250	D	H_2S.
200-925-1	V. Bergman	a1933	Drl	r64	6	--	do.	1,585	r15	--	Dw	300	D	Iron; water-bearing zone may be coarse material on top of bedrock; csg 64 ft (r).
-2	P. Allen	a1930	Drl	37	6	--	Sand and gravel	1,560	16.0	9/27/62	Sw	150	D	Supplied 42 cattle until 1959. Water-bearing material may be sand and gravel lense in till.
200-926-1	D. Sweeney	a1936	Drl	r122	6	r109	Bedrock	1,435	+0.7	9/20/62	Sw	280	D, F	Temp 50.3 9/20/62; H_2S; flow 1 gpm at 0.4 ft above LS.
-2	F. Maloy	a1930	Drl	57	5	--	Sand	1,450	17.4	9/27/62	Sw	640	D, F	Csg 57 ft (r).
-3	D. Reese	1951	Drl	r90	6	r80	Bedrock	1,450	r32	6/ /51	Dw	150	D	
200-927-1	E. Winderl	1953	Drl	r253	5	r200	do.	1,440	(r)flows	--	Sw	400	D, C	Gas.
-2	M. Johnson	1906	Drl	r260	4	a200	do.	1,440	(r)flows	--	Sw	900	D, F	H_2S; gas; well supplies three families.
-3	M. Ireland	a1920	Drl	26	6	--	Sand	1,465	16.4	9/19/62	Sw	550	D, F	
-4	G. Fowler	1904	Dug	26	36	--	Till	1,465	19.6	9/11/62	Sw M	140	D, F	Used intermittently.
-5	do.	a1930	Drl	r77	6	r37	Bedrock	1,465	--	--	Sw	140	D, F	H_2S; inadequate in summer; csg 40 ft (r).
-6	R. Cross	1959	Drl	r115	4	r111	do.	1,425	r5	8/ /59	Sw	600	D	Gas; csg 112 ft (r); supplies two families.
201-909-1	J. Dwyer	1960	Drl	r160	6	r100	do.	1,260	(r)flows	--	Sw	200	D	Log; H_2S.
-2	W. Sherman	--	Drl	r90	6	a90	do.	1,240	flows	--	Sw	600	D, F	Anal; temp 51.0 8/16/61; H_2S; flows when pump is not running.
-3	do.	--	Drl	?121	8, 6	a100	do.	1,240	+1.7	8/16/61	--	--	A	Anal; temp 55.0 8/16/61; gas; former oil well; measured water level is between 6-inch and 8-inch casings; depth of interior well is 121 ft below LS and may be plugged; oil on water inside 6-inch casing at 50 ft below LS.
-4	H. Strand	1940	Drl	26	12	--	Sand	1,260	9.3	8/17/61	Sw	200	D	Gravel packed.
-5	do.	--	Dug	9	24	--	Sand and gravel	1,260	7.0	8/17/61	Sw	--	C	Supplies water for greenhouse.
-6	N. Reynolds	1954	Drl	r97	6	r90	Bedrock	1,280	--	--	Dw	200	D	
-7	W. Hanson	--	Drv	r15	1 1/4	--	Sand and gravel	1,240	r10	--	Sw	500	D, F	Finished with screened drive point.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing material	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
201-910-1	L. Johnson	--	Dug	i6	24	--	Gravel	1,250	11.1	8/17/61	Sw	400	D, F	Supplies two houses.
-2	K. Dahlgren	--	Drl	r60	6	a60	Bedrock?	1,260	--	--	Dw	350	D, F	
201-916-1	G. Schaffer	b1940	Drl	r40	4	--	Sand and gravel	1,340	r20	8/19/60	Sw M	200	D, F	H_2S.
-2	A. Cook	--	Dug	r30	24	--	do.	1,340	--	--	Sw	250	D	
-3	W. Peterson	1950	Drl	r138	6	r50	Bedrock	1,335	r5	7/ 7/61	Dw	150	D	Log; gas; salty (slightly); flows in spring (r).
201-917-1	Bar-B-Ranch, Inc.	1951	Drl	r39	6	--	Sand and gravel	1,350	e4	9/21/60	Dw	s100,000	C	Yield 100 gpm (r); supplies commercial swimming pool and restaurant; equipped with two pumps.
-2	do.	1951	Drl	r22	6	--	Gravel	1,350	3.7	9/21/60	Sw	s100,000	C	Yield 200 gpm (r); supplies commercial swimming pool in summer (unused in winter).
-3	Town of Busti	1961	Drl	r75	6	--	Sand and gravel	1,350	11.6	6/ 7/61	Sw M	--	U	Anal; temp 51 6/7/61; much fine sand in water.
-5	R. Boswell	--	Drv	r21	1 1/4	--	Sand	1,350	0.8	6/ 8/61	--	--	A	Formerly supplied milk house.
-6	Town of Busti	--	Drl	r156	6	a100	Bedrock	1,350	--	--	Dw	200	PS	Anal; gas; salty; iron; oil film on water (r); used for sanitary purposes only.
-7	Busti Fire Dept.	--	Drl	198	8	a137	do.	1,340	9.4	7/ 7/61	--	--	A	Temp 48.8 6/6/63; csg 137 ft; abandoned because of quality.
-8	do.	1952	Drl	r109	6	r52	do.	1,355	--	--	Dw	--	In	Log; quality is reported as fair.
201-924-1	H. Faulkner	1922	Drl	69	4	--	Sand and gravel	1,540	10.3	9/28/62	Sw	1,300	D, F	H_2S.
-2	B. Rendell	1951	Drl	r81	6	r81	Bedrock, sand	1,475	r9	1951	Dw	s200 w1,600	D. F	Water-bearing material is probably unconsolidated material on top of the bedrock.
201-926-1	U.S. Geological Survey	1961	Aug	127	3	--	Sand	1,440	2.0	7/17/61	--	--	T, De	Log.
-2	Unknown	--	Dug	11	36	--	do.	1,445	9.6	9/18/62	--	--	A	House and well have been abandoned for several years.
-3	H. Covert	1950	Drl	r232	4	a200	Bedrock	1,440	--	--	Dw	400	D, F	H_2S; flows in spring (r).
-4	D. Edwards	--	Dug	12	20	--	Sand	1,440	7.9	9/19/62	Sw	150	D	Inadequate in summer.
201-927-1	F. Willetts	a1930	Dri	r68	6	--	Gravel	1,460	--	--	Sw	1,200	D, F	
-2	E. Pierce	a1920	Drl	r65	5	--	Sand and gravel	1,450	--	--	Dw	200	D	
202-914-1	W. Normand	1957	Drl	r167	4	r165	Bedrock	1,320	r10	1957	Dw	100	D	Log; anal; H_2S; iron; yield 4 gpm (b); csg 165 ft (r).
-2	do.	1949	Drl	r160	6, 4	r160	Gravel, bedrock	1,310	r33	--	Dw	200	D	H_2S; iron; inadequate during heavy use; water-bearing meterial is gravel on top of bedrock (r).
202-916-1	Busti Fire Dept.	1952	Drl	r86	6	--	Sand and gravel	1,365	r5	--	Dw	--	PS	Used intermittently.
-2	J. Boswell	--	Dug	14	21	--	do.	1,350	9.8	6/ 8/61	Sw	300	D, C	Inadequate during summer 1960.
-3	L. Brown	--	Dug	13	--	--	Sand	1,340	6.7	7/ 7/61	Sw	150	D	Inadequate during dry summers.
-4	L. Stevens	1952	Drl	r188	6	a100	Bedrock	1,350	--	--	Dw	150	D	Anal; gas; salty; oil film on water (r); driller reports over 100 ft of blue clay; used for sanitary purposes only.
202-917-1	Town of Busti	--	Dug	r26	36	--	Sand	1,370	--	--	Sw M	--	PS	Used intermittently.
-2	W. Flagg	--	Dug	12	24	--	Till	1,365	5.5	7/ 7/61	Sw	250	D	Occupant reports "strange" taste.
-3	E. Vandewark	1952	Drl	r116	6	r111	Bedrock	1,410	r8	1961	Dw	s500 w1,500	D, F	Log; H_2S; iron.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing material	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
202-917-4	Church of God	1952	Drl	r153	6	r130	Bedrock	1,350	--	--	--	--	In	
202-923-1	H. Meloy	1960	Drl	r99	4	r94	do.	1,480	r32	4/ /60	Dw	s250 w1,550	D, F	Deepened from 94 to 99 ft below LS in 1960.
202-924-1	U.S. Geological Survey	1961	Aug	102	3	--	Sand	1,450	5.0	7/17/61	--	--	T, De	Log.
-2	E. Blytha	1958	Drl	r70	6	--	Sand and gravel	1,450	+0.7	10/ 1/62	Sw	150	D	Temp 50.2 10/1/62; flows greater than 1 gpm at 0.2 ft above LS.
-3	F. Stevens and R. Knapp	1954	Drl	r152	6	--	do.	1,450	--	--	Dw, Sw	350	D	Iron; flows in spring (r); supplies two families.
-4	G. Johnson	a1930	Drl	108	7	--	do.	1,450	27.9	10/ 3/62	Dw	s750 w1,350	D, F	
-5	South Harmony Grange	--	Dug	16	28	--	Sand	1,450	11.2	10/ 3/62	Sw M	--	In	Used intermittently.
-6	M. Smith	--	Dug	21	24	--	do.	1,455	19.0	10/ 4/62	Sw	250	D	
-7	H. Furlow	a1920	Dug	24	24	--	Sand and gravel	1,455	15.6	10/ 4/62	Sw	100	D	
-8	W. Yager	a1922	Drl	r68	5	--	do.	1,450	+1.7	10/ 3/62	Sw	250	D	Temp 51 10/3/62.
202-925-1	H. Johnson	1955	Drl	r355	7	r293	Bedrock	1,460	r23	9/ 3/55	Dw	200	D, F	Log; anal; gas; salty; inadequate; yield 15 gph (r); csg 292 ft (r).
203-909-1	Village of Frewsburg	1940	Drl	128	10, 8	r117	do.	1,310	(r)flowed	10/ /40	--	--	T, De	Log; inadequate; flow of less than 1 gpm (r).
-2	do.	1940	Drl	200	10, 6	r126	do.	1,315	r25	11/ /40	--	--	T, De	Log; inadequate; yield of 5 gpm (b).
203-910-1	U.S. Geological Survey	1961	Aug	32	3	--	Sand	1,240	--	--	--	--	T, De	Log.
-2	Kling Factories	--	Dug	r10	240	--	Sand and gravel	1,260	r3	--	Sw	10,000	I	
-3	Plastic Case Corp.	--	Dug	r12	36	--	Gravel	1,260	--	--	Sw	--	I	Water filtered before use.
203-911-1	R. Akin	1942	Drv	r27	1 1/4	--	Sand	1,240	r10	--	Sw	300	D	Finishad with screened drive point.
-2	do.	--	Drv	r20	1 1/4	--	do.	1,240	r7	--	Sw	1,000	F	Do.
-3	do.	--	Drl	r169	4	--	Bedrock?	1,240	(r)flows	--	--	--	A	H_2S; gas; well abandoned because of poor quality.
-4	T. Cowan	--	Drv	r20	1 1/4	--	Sand	1,260	flows	8/24/61	Sw	250	D	Flows 1 gpm at 1.0 ft above LS.
-5	N.Y.S. Dept. Pub. Wks.	1959	Drl	86	2	78	do.	s1,245.3	r8.7	12/ 8/61	--	--	T, De	Log.
-6	U.S. Geological Survey	1962	Drl	225	6	--	Sand and gravel	1,245	6.2	7/31/62	--	--	T, A	Do.
203-912-1	do.	1961	Aug	87	3	--	Sand	1,250	6.3	7/18/61	--	--	T, De	Do.
-2	Kiantone Fire Dept.	1961	Drl	122	6	--	do.	1,260	flows	8/17/61	Dw	--	PS	Log; temp 51.0 8/3/61; flows less than 1 gpm; yield 5 gpm (r).
-3	J. A. Jacobson Dairy	1952	Drl	r65	6	--	Gravel	1,260	(r)flows	--	Sw	8,000	I	Anal; H_2S; inadequate during peak demand; yield 18 gpm (r).
-4	do.	--	Drl	r164	12	r164	Sand and gravel	1,260	--	--	Dw	8,000	I	Log; inadequate during peak demand.
-5	A. Ellison	1948	Drl	r101	6	--	Gravel	1,250	r+6	--	Sw	400	D	Anal; H_2S.
-6	J. Brown	--	Drv	r75	1 1/4	--	Sand and gravel	1,250	--	--	Sw	200	D	Anal; H_2S; iron; finished with screened drive point.
-7	B. Brett	1922	Drl	r95	4	r72	Bedrock	1,275	r40	11/ /62	Dw	150	D	Csg 75 ft (r).
-8	H. Bratt	1961	Drl	r85	6	r60	do.	1,290	flows	--	Dw	200	D	Flows greater than 4 gpm at 3 ft below LS; csg 71 ft (r).

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing material	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
203-913-1	R. Kindland	--	Drv	r30	1 1/4	--	Sand and gravel	1,270	flows	--	Sw	300	D	Anal; flows 5 gpm (r); finished with screened drive point.
-2	H. Davis	--	Drv	r20	1 1/4	--	Gravel	1,270	r5	--	Sw	200	D	Finished with screened drive point.
-3	F. Wall	1959	Drv	r25	1 1/4	--	do.	1,270	r10	--	Sw	100	D	Do.
-4	R. Hodges	1958	Drl	r43	4	--	do.	1,260	--	--	Dw	300	D	Anal; inadequate during heavy use; occupant reports strange "metallic" taste.
-5	C. Swanson	--	Drv	r10	1 1/4	--	Sand	1,260	e6	8/23/61	Sw	300	D	Inadequate in summer; finished with screened drive point.
-6	do.	1958	Drv	7	1 1/4	--	do.	1,260	5.8	8/23/61	--	--	A	Inadequate; finished with screened drive point.
203-917-1	R. Kelly	1959	Drl	r112	6	r90	Bedrock	1,620	--	--	Dw	250	D	Log; H_2S; iron; yield 25 gpm (b).
203-923-1	R. Neil	a1920	Dug	10	36	--	Sand	1,380	7.9	10/ 8/62	Sw	250	D	Inadequate; yield decreasing; may be filling with fine sand.
203-924-1	L. Van Tassel	1910	Drl	r330	6, 4	r218	Bedrock	1,445	r21	4/ /52	Dw	200	D, F	Log; inadequate; csg 330 ft (r); driller reports gas at 65 ft below LS.
203-925-1	R. Brown	a1922	Dug	17	36	--	Sand and gravel	1,470	8.3	10/ 4/62	Sw	150	D	Well once supplied 20 livestock.
203-929-1	N.Y.S. Conservation Dept.	--	Dug	33	36	--	Till	1,750	F3.4	3/10/62	--	--	D	Temp 51 6/27/56.
204-905-1	W. Miller & M. Walrod	1957	Drl	r267	4	--	Gravel	1,280	(r)flows	--	Sw	300	D	Flows 1 gpm at 4 ft below LS (r); driller reports hitting a tree log at about 200 ft below LS.
204-906-1	M. Wald	1961	Drl	r166	7	r127	Bedrock	1,290	r4	3/ /61	Sw	150	D	Log; H_2S.
204-909-1	Village of Frewsburg	1941	Drl	40	12	--	Sand and gravel	1,250	4.5	10/ 4/62	Dw	80,000	PS	Log; anal; yield 158 gpm with 11.9 ft of dd; flows in spring; no. 80 slot, 6-inch well screen from 35.5 to 40.0 ft below LS.
-2	do.	1941	Drl	40	12	--	do.	1,250	4.5	10/ 4/62	Dw	80,000	PS	Log; anal; pt; yield 150 gpm with 12.0 ft of dd; flows in spring; no. 80 slot, 6-inch well screen from 34.2 to 39.6 ft below LS.
-3	R. Campbell	1948	Drv	r34	1 1/4	--	do.	1,250	(r)flowed	1948	Sw	100	D	Log; yield 10 gpm (r).
-4	R. Young	1960	Drl	r52	6	--	Gravel	1,255	--	--	Sw	150	D	
-5	Village of Frewsburg	--	Drl	34	1 1/2	--	Sand and gravel	1,250	5.8	11/ 8/62	--	--	O	
-6	do.	1964	Drl	50	4	--	do.	1,240	r3	4/30/64	--	--	T	Log; pumped at 50 gpm.
204-911-1	T. Cowan	1961	Drl	104	6	r95	Bedrock	1,290	19.5	8/24/61	--	--	D	Log; csg 104 ft (r); will be used as household supply.
-2	do.	--	Drl	r150	4	r85	do.	1,280	--	--	Sw M	--	D	Salty; used for washing only.
-3	L. Fitzpatrick	1959	Drl	r300	6	a100	do.	1,300	--	--	Dw	200	D	H_2S.
-4	L. Peterson	a1924	Drl	r114	6	a90	do.	1,340	r33	6/ /60	Dw	250	D	Csg 90 ft (r); inadequate with shallow well pump.
204-915-1	R. Cornell	1962	Drl	70	6	46	do.	1,370	p17.0	6/28/62	--	--	D	Log; yield 3 gpm (b); principal water-bearing zone may be fine sand at the top of bedrock.
204-922-1	E. Miller	1960	Drl	r40	6	--	Gravel	1,380	r7	--	Dw	200	D	Log; yield 12 gpm (b).
-2	do.	--	Dug	9	24	--	Sand	1,380	3.6	6/28/62	--	--	A	
-3	A. Lindblom	1953	Drl	r193	6	--	Gravel	1,370	r18	1953	Dw	200	D	Gas; iron; used for sanitary purposes only.
-4	G. Smith	1952	Drl	r194	6	--	Bedrock	1,390	r22	--	Dw	150	D	H_2S; gas; iron.
204-923-1	R. Seekins	1941	Drv	r18	1 1/4	--	Sand	1,365	--	--	Sw	200	D	Finished with screened drive point.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing material	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
204-923-2	R. Swanson	1953	Drv	r22	1 1/2	--	Sand	1,360	--	--	Sw	450	D	Inadequate during heavy use; finished with a screened drive point.
-3	C. James	1960	Dug	r29	24	--	Sand and gravel	1,350	r20	10/ /60	Sw	300	D	
-4	do.	1952	Drl	r93	6	--	Gravel	1,350	--	--	--	--	De	Log.
204-924-1	MacDonald's Grocery	1953	Drl	r200	6	r185	Bedrock	1,400	--	--	Dw	150	C	Log; gas; inadequate.
-2	R. Larson	--	Dug	r22	24	--	Sand	1,510	r17	6/ /57	Sw	100	D	
-3	W. Linamen	1949	Drl	r126	6	--	Sand and gravel	1,460	r21	9/ /49	Dw	200	D	
-4	C. Swanson	1946	Drl	r46	6	--	do.	1,430	r11	8/ /46	Dw	150	D	
205-906-1	H. Springer	1949	Drl	r63	6	--	do.	1,340	r9	12/ /49	Dw	800	D, F	
205-907-1	E. and D. Springer	a1928	Jet	r264	2	--	do.	1,260	r+23	--	--	--	D, F	Temp 49.5 8/16/60; H_2S; yield 40 gpm (b); flows 7.5 gpm at 2.7 ft above LS.
-2	C. Lindstrom	a1922	Jet	r378	2, 1	--	Gravel	1,250	r+35	--	Sw	--	D, F	Log; H_2S.
-3	T. Peterson	--	Drl	r350	6	r340	Bedrock	1,260	+12.4	9/12/61	Sw	700	D, F	Anal; H_2S; temp 52.0 9/12/61; flows 6 gpm at 3.9 ft above LS.
-4	R. Berot	--	Drl	r47	2	--	Gravel	1,245	+2.3	11/ 7/61	--	150	D	H_2S; temp 49.5 11/7/61; flows 3.3 gpm at 1.0 ft above LS.
-5	N.Y.S. Dept. Pub. Wks.	1958	Drl	100	2	--	Sand and gravel	s1,243.1	r+6.0	9/ 3/58	--	--	T, De	Log; flowed 16 gpm at LS; water-bearing zone from 40 to 41.5 ft below LS; well was allowed to flow overnight and caused well 205-907-4 to stop flowing.
-6	do.	1958	Drl	50	2	--	Silt, sand, and gravel	s1,242.5	r3.3	9/11/58	--	--	T, De	Log.
205-908-1	J. Forbes	--	Drl	143	7	--	Sand and gravel	1,240	4.0	6/ 6/63	--	--	F	Temp 49.8 6/6/63; gas; inadequate; csg 134 ft.
-2	U.S. Geological Survey	1961	Aug	112	3	--	Gravel	1,240	flowed	7/19/61	--	--	T, De	Log; temp 49.0 7/19/61; flowed about 15 gpm at LS; water-bearing zone from 94 to 96 ft below LS.
205-909-1	G. Gustaveson	1957	Drl	r88	7	--	do.	1,250	flows	6/15/61	Sw	120	F	Log; anal; temp 50.0 6/15/61; H_2S; iron; yield 50 gpm with 12 ft of dd.
-2	G. Stimson	1934	Drl	r86	6	--	Sand and gravel	1,310	r35	5/ /60	Dw	250	D	
-3	A. Carlberg	1962	Drl	r225	7	r152	Bedrock	1,275	52.4	12/ 4/62	Dw	1,700	D, F	Log; gas; iron; csg 172 ft (r); occupant reports disagreeable taste. When well entered bedrock at 152 ft a large reservoir of gas was tapped. Gas flowed at a rate of 9.5 million cubic ft per day at 2:00 p.m. on 2/12/62 (r). This flow quickly declined and 20 days later drilling was resumed.
205-910-1	H. Leonard	--	Drl	r100	6	--	Sand and gravel	1,350	--	--	Dw	200	D	
-2	C. Ames	a1902	Drl	r40	4	--	do.	1,330	r25	7/ /61	Dw	1,160	D, F	Yield 20 gpm (r).
-4	M. Haskins	1959	Drl	21	7	--	Gravel	1,310	9.6	12/ 4/62	Sw	s15,000	Ir	Log; yield 150 gpm (r); finished with 3 ft of slotted casing.
205-911-1	E. Ogren	1932	Drl	74	5	--	Gravel?	1,375	17.9	11/23/60	Dw	100	D	Anal; iron; well may end or be obtaining water from bedrock.
205-914-1	Unknown	1895	Drl	r3,360	6	r180	Bedrock	1,350	r20	1905	--	--	De	Log.
-2	N.Y.S. Dept. Pub. Wks.	1957	Drl	101	2	--	Gravel	s1,354.0	r21.5	11/ 8/57	--	--	T, De	Log; principal water-bearing zone 33 to 43 ft below LS.
-3	do.	1957	Drl	103	2	--	Sand	s1,311.0	r4.0	10/11/57	--	--	T, De	Log.
-4	do.	1957	Drl	112	2	--	do.	s1,309.3	r1.9	10/11/57	--	--	T, De	Do.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
205-914-5	N.Y.S. Dept. Pub. Wks.	1957	Drl	51	2	41	Bedrock	s1,318.5	r9.5	11/ 7/57	--	--	T, De	Log.
-6	do.	1959	Drl	24	2	13	do.	s1,339.0	r11.0	10/15/59	--	--	T, De	Do.
-7	do.	1959	Drl	44	2	39	do.	s1,353.7	rdry	10/ 9/59	--	--	T, De	Do.
205-920-1	D. Masters	1957	Drl	r67	6	--	Sand and gravel	1,340	r23	1957	Dw	200	D	Iron; yield greater than 8 gpm (b).
-2	P. Pihl	1931	Drl	r34	6	r32	Bedrock	1,350	(r)flows	--	Sw	100	D	Equipped with two shallow well pumps (one electric and one manual).
205-921-1	L. James	1960	Drl	r74	6	--	Sand and gravel	1,315	13.4	12/14/60	--	--	C	Inadequate; used for bait fish pond.
-2	Village of Lakewood	1952	Drl	r30	18	--	Sand, gravel, clay	1,315	r5	7/ 7/52	--	--	T, De	Log; inadequate.
-3	F. Conover	1950	Drv	r35	1 1/4	--	Sand	1,315	r6	5/ /50	Sw	100	D	Finished with screened drive point.
-4	N. Olson	1942	Drl	r48	8	r44	Bedrock	1,330	(r)flows	--	Sw	300	D	
-5	D. White	1958	Drl	27	6	--	Sand and gravel	1,320	5.3	11/27/62	Sw	150	D	Log; originally drilled to 57 ft below LS; casing pulled back to present depth.
205-922-1	G.L.F. Service, Inc.	a1954	Drl	25	5	--	do.	1,320	10.8	8/19/60	Dw	750	C	Iron; hardness - 273 ppm (r).
-2	Panama Central School District	--	Drv	r25	1 1/4	--	do.	1,325	--	--	Sw	800	In	Supplies 80 percent of water used by the school.
-3	D. Simmons	1961	Drl	r91	6	--	Gravel	1,340	1.3	10/ 9/62	Sw	100	D	Log; anal; temp 50.8 10/9/62; flows greater than 2 gpm at 3.0 ft below LS.
-5	B. Johnson	1962	Drl	r48	6	--	Sand and gravel	1,375	r15	9/29/62	Dw	--	D	Yield 30 gpm (r).
-6	R. Davenport	1953	Drl	r42	6	--	Gravel	1,350	--	--	Dw	200	D	
-7	L. Graham	1932	Drl	r98	4	r96	Bedrock	1,335	r14	--	Sw	100	D	Log; H_2S.
-8	M. Manhert	1936	Drl	r62	6	--	Sand and gravel	1,335	r10	8/ /61	Dw	250	D	
-9	C. King	1950	Drl	r106	6	--	do.	1,340	(r)flows	--	Dw	300	D	H_2S.
-10	C. Bush	1956	Drl	r170	6	r158	Bedrock	1,340	r17	--	Dw	200	D	H_2S; iron; csg 160 ft (r).
-11	W. Hosler	1945	Drl	r49	6	--	Sand and gravel?	1,330	r26	12/18/59	Dw	100	D	
206-903-1	M. Hoover	1957	Drl	r80	5	r68	Bedrock	1,465	r17	10/ /57	Dw	150	D	
-2	R. Lundberg	1960	Drl	r94	5	--	Gravel	1,420	r18	7/ /62	Dw	1,300	D, F	Log; yield 16 gpm (b).
-3	R. Glendinning	1952	Drl	20	6	--	Sand and gravel	1,400	14.5	9/14/62	Sw	440	F	Inadequate during summer.
206-907-1	E. Grout	1915	Drl	r42	6	--	Gravel	1,290	--	--	Dw	1,500	F	Log.
-2	do.	a1915	Drl	r58	6	--	do.	1,300	--	--	Dw	300	D	Supplies two houses.
206-908-1	J. Ceresa	1939	Drl	r83	4	--	Sand and gravel	1,250	--	--	Sw M	50	D	Log; anal; H_2S (slight); flowed when drilled; finished with perforated casing.
-2	J. Whitmore	1958	Drl	54	6	--	Gravel	b1,243	6.3	6/ 7/63	Sw	200	D	Flowed when drilled (r).
-3	C. Lindstrom	b1930	Drl	?	8	--	Bedrock?	b1,267	5.6	10/ 5/60	--	--	A	Partially (?) plugged 10 ft below LS.
-4	do.	a1929	Drv	r32	1 1/4	--	Sand and gravel	1,250	--	--	Sw	1,000	F	Log; anal; yield 10 gpm (r).
-6	U.S. Geological Survey	1962	Drl	150	6	--	do.	1,245	--	--	--	--	T, A	Log; csg 139 ft; only water-bearing zone from 41 to 48 ft below LS.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
206-909-1	City of Jamestown	1926	Drl	r315	?6	r310	Bedrock, sand	1,245	(r)flows	--	Dw	--	I	Log; iron; flows at 30 gpm (r); yield 200 gpm (r); water contains silt when pumped; used for sewage processing; pumped for extended periods of time at 150 gpm.
-2	A. Carlberg	1957	Drl	r90	7	--	Sand and gravel	1,245	--	--	--	--	F	
-3	E. Stahlman	--	Drl	r156	6	?	Bedrock	1,270	r10	--	Dw	100	D	
206-910-1	I. Quaint	a1946	Jet	r103	4.5	--	Sand and gravel	1,280	r+18	--	Sw	100	D	Anal; temp 49.2 8/26/60; flows 6 gpm about 4 ft below LS at well.
-2	M. Engle	--	Drl	r165	6	?	Bedrock	1,285	--	--	--	--	D	
-3	Hildom Cinder Block Co.	a1948	Drl	r60	7	--	Gravel	1,305	r10	1948	Dw	2,000	I, D	Yield 50 gpm (b).
-4	M. Crandell	--	Drl	r57	4	--	do.	1,320	r19	--	Dw	900	D, F	Supplies two families.
-5	H. Crowl	--	Drl	r220	6	?	Bedrock	1,270	--	--	Dw	100	D	
-6	F. Quaint	--	Dug	r22	36	--	Sand and gravel	1,270	r10	--	Sw	200	D	
-7	W. Krocyl	1960	Drl	r60	6	--	Gravel	1,310	r31	5/ /60	Dw	200	D	Well deepened from 55 to 60 ft below LS in 1960; screened.
206-911-1	Flickenger Cold Storage Co.	--	Drl	r45	6	--	Sand and gravel	1,265	--	--	Dw	--	I	Anal; temp 47 8/26/60; used intermittently for refrigeration.
-2	Falconer Plate Glass Co.	1947	Drl	r84	10	--	Gravel	1,265	--	--	Dw	54,000	I	Anal; pumped at 100 gpm with 10 ft of dd; maximum yield 240 gpm (r).
-3	do.	a1957	Drl	r84	8	--	do.	1,265	--	--	Dw	400	I	Log; yield 150 gpm with 8 ft of dd (r).
-4	Falconer Furniture Co.	1945	Drl	145	8	--	Sand and gravel	b1,256	14.3	3/27/62	--	--	U	Log; yield 134 gpm with 80 ft of dd; csg 139 ft (r); 17 ft of no. 80 slot well screen (screen may be partially filled).
-5	National Worsted Mills	a1944	Drl	r42	12	--	Gravel	1,260	--	--	Dw	100,000	I	Log; anal; temp 54.0 3/28/61; yield 300 gpm (r); csg 38 ft; 4 ft of 6-inch well screen.
-6	do.	1950	Drl	r42	12	--	do.	1,255	p12.2	3/28/62	Dw	200,000	I	Log; yield 450 gpm (r); csg 38 ft; 4 ft of 6-inch well screen.
-7	do.	1950	Drl	r42	12	--	do.	1,255	p11.9	3/28/62	Dw	200,000	I	Do.
206-912-1	Jamestown Mallable Iron Corp.	1950	Drl	r45	12	--	do.	1,260	r9	--	Dw	w360,000	I	Log; anal; yield 500 gpm with 7.5 ft dd; screen length 1.5 ft; not used in summer when it interferes with nearby well.
-2	do.	1950	Drl	50	12	--	do.	1,260	p18.6	3/27/62	--	--	O	Log; yield 350 gpm (r).
-3	do.	1950	Drl	r34	12	--	do.	1,260	r17	--	Dw	250,000	I	Log; anal; temp 47 3/27/62; inadequate in summer if well 206-912-1 is pumped; yield 350 gpm (r); finished with 1.6 ft of screen.
-4	do.	1950	Drl	35	12	--	do.	1,260	p14.1	3/27/62	--	--	O	Log.
-5	Royal Metal Mfg. Co.	1951	Drl	r48	10	--	Sand and gravel	1,280	r15	--	Dw	--	U	Inadequate; equipped with two pumps.
-6	Jamestown Sterling Corp.	--	Drl	r33	8	--	do.	1,275	r13	--	Sw	27,000	I	Yield 30 gpm (r).
-7	Lake County Furniture Corp.	--	Drl	r35	8	--	do.	1,275	r12	--	Sw	10,000	I	
-8	W. Rowan Ready Mix Concrete Co.	1955	Drv	r22	1 1/2	--	do.	1,275	--	--	Sw	--	I	Used occasionally.
-9	do.	--	Drv	r26	1 1/2	--	do.	1,275	r10	--	Sw	12,000	I	Anal.
-10	Niagara-Mohawk Corp.	--	Drl	r25	6	--	do.	1,260	--	--	Sw	--	A	Inadequate; yield 30 gpm (r).

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
206-912-11	Hope's Windows	1940	Drl	163	6	--	Gravel	1,270	p104.0	3/30/62	Dw	24,000.	I	Log; inadequate; yield 50 gpm; 30 ft of dd at 50 gpm; screened from 155 to 163 ft below LS.
-12	do.	1954	Drl	163	6	--	do.	1,270	r60	10/23/56	--	--	T, A	Log; screened from 161.5 to 163 ft below LS; never used because of interference with well 206-912-11.
-13	New Way Restaurant	1951	Drl	r45	6	--	do.	1,265	r12	--	Sw	--	C	Yield 90 gpm (r); used for air conditioning.
-14	Blackstone Corp.	--	Drl	r50	--	--	Sand	1,270	--	--	--	--	T, De	Log.
-15	Jamestown Mallable Iron Corp.	--	Drl	r145	--	r138	Gravel	1,270	--	--	--	--	T, De	Log; yielded 10 gpm from gravel at 15 to 18 ft below LS.
-16	do.	--	Drl	r228	--	r200	do.	1,260	rdry	--	--	--	T, De	Gas and oil (trace).
206-914-1	Peter C. Bendo, Inc.	1935	Drl	r316	6	r212	Bedrock	1,315	--	--	--	--	T, De	Log; salty; inadequate.
-2	P. Petrino	--	Drl	r67	6	--	Gravel	1,320	(r)flows	--	--	--	C, A	Flows 44 gpm (r).
206-915-1	City of Jamestown	1937	Drl	r231	12, 8	r231	Sand and gravel	s1,310.4	r9	8/ 5/37	--	--	T, De	Log; inadequate; 12-inch csg 200 ft; 8-inch csg 231 ft.
-2	do.	1937	Drl	r245	12, 8	r239	Bedrock	s1,310.4	--	--	--	--	T, De	Log; inadequate; 12-inch csg 220 ft; 8-inch csg 239 ft.
-3	Chautauqua Lake Creamery	--	Drl	80	8	--	Sand and gravel	1,340	p17.7	7/17/62	Dw	10,000	I	Yield 20 gpm.
-4	Rockwell Manufacturing Co.	--	Drl	r34	12	--	Gravel	1,315	r6	--	Sw	100,000	I	Anal; yield 200 gpm with 15 ft of dd.
-5	Art Metal Corp.	--	Drl	r80	6	--	do.	1,315	(r)flows	--	Sw	185,000	I	H_2S; yield 300 gpm (r).
206-918-1	Village of Lakewood	1961	Drl	r72	20, 10	--	do.	1,320	r35	7/10/62	Dw	400,000	PS	Yield 350 gpm with 31 ft of dd; screen length 10 ft.
206-921-1	do.	--	Drl	r30	18	--	Sand and gravel	1,315	--	--	Dw	--	PS, U	Used as auxiliary well only.
-2	do.	--	Drl	r37	18	--	do.	1,315	--	--	Dw	--	PS, U	Do.
-3	do.	1952	Drl	r55	8	--	do.	1,315	r8	6/ /52	--	--	T, De	Log; yield 112 gpm with 5 ft of dd.
-4	do.	1952	Drl	r35	8	--	do.	1,315	r11	6/ /52	--	--	T, De	Log; yield 160 gpm with 4.2 ft of dd.
-5	E. Loomis	1959	Drl	99	6	--	Gravel	1,315	1.9	6/18/62	--	--	A	Log; H_2S; inadequate.
-6	D. Messler	1962	Jet	85	2	--	Sand	1,315	4.0	7/10/62	Sw	s200	D	Log; supplies summer camp.
-7	E. Loomis	1962	Jet	r85	2	--	do.	1,310	--	--	--	--	T, De	Log; pumped 0.5 gpm (r).
-8	M. Simpson	a1930	Drl	31	6	--	Sand and gravel	1,315	2.3	10/12/62	Sw	100	De	Occupant reports that well flowed until village of Lakewood wells (600 ft to south) were installed.
-9	I. Larson	1952	Drv	r28	1 1/2	--	do.	1,320	r11	7/ /60	Sw	100	D	Log; affected by pumping of village of Lakewood (auxiliary well field).
-10	C. Olson	1948	Drv	30	1 1/2	--	do.	1,315	1.6	10/12/62	Sw	200	D	
206-922-1	Unknown	1962	Drl	r78	1 1/2	--	do.	1,310	2.6	7/10/62	Sw	--	D	
-2	R. Comp	1960	Drv	r78	1 1/2	--	do.	1,310	r5	--	Sw	s200	D	Supplies summer camp.
207-903-1	L. Bowen	a1930	Drl	r97	3	?	Bedrock	1,520	--	--	Dw	450	D	Iron; supplies two families.
-2	W. Ellis	1922	Drl	r70	4	--	Sand and gravel?	1,480	r8	7/ /62	Dw	700	D, F	
207-905-1	U.S. Geological Survey	1961	Aug	72	3	--	Sand and gravel	1,295	--	--	--	--	T, De	Log.
-3	M. Anderson	1959	Drv	r13	1 1/4	--	do.	1,270	--	--	Sw	200	D	

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
207-905-4	M. Anderson	--	Drv	r19	1 1/4	--	Sand and gravel	1,280	r7	--	Sw	1,500	F	
-5	S. Walrod	--	Drv	r22	1 1/4	--	do.	1,300	r5	--	Sw M	--	D	Used intermittently.
-6	L. Town	1956	Drv	r26	1 1/4	--	do.	1,290	r6	--	Sw	150	D	
-7	A. Vanstrom	1951	Drl	r26	6	--	Gravel	1,295	--	--	Sw	600	D	Iron; occupant reports "metallic" taste.
207-906-1	G. Robbins	--	Drv	r86	1 1/4	--	Sand and gravel	1,250	--	--	Sw	150	D	
-3	A. Boe	--	Drv	r90	1 1/4	--	do.	1,250	r10	--	Sw	300	D, F	H_2S.
-4	O. Carlson	1960	Drl	r138	6	--	Sand	1,290	--	--	Dw	2,000	F	Log; H_2S.
-5	do.	1961	Drv	r22	1 1/4	--	Sand and gravel	1,290	r10	--	Sw	--	U	Finished with screened drive point.
-6	U.S. Geological Survey	1962	Drl	79	6	--	do.	b1,245	F8.9	8/14/62	--	--	T, O	Log; anal; pt; temp 49.5 8/8/62; H_2S; no. 25 slot screen from 69 to 79 ft below LS; water-level fluctuations recorded from Sept. to Oct. 1962; much wood and organic material found from 10 to 18 ft below LS.
-7	do.	1962	Drl	67	6	--	do.	b1,242	F7.9	8/23/62	--	--	T, O	Log; temp 49.2 10/11/62; 2-inch well screen from 63.6 to 66.6 ft below LS; water-level fluctuations recorded from Oct. 1962 to June 1963.
-8	do.	1962	Jet	50	1 1/4	--	do.	b1,241	4.5	11/ 5/62	--	--	O	Log.
-9	City of Jamestown	1964	Drl	90	6, 4	--	do.	1,240	r8	5/28/64	--	--	T	Log; yield 60 gpm with 6.7 ft of dd (r).
-10	do.	1964	Drl	130	6	--	do.	1,240	r12	6/ 2/64	--	--	T	Log; yield 15 gpm (r); 2-inch screen to depth of 21 ft below LS.
-11	do.	1964	Drl	90	6	--	do.	1,240	r8	6/ 5/64	--	--	T	Log; yield 55 gpm (r); 2-inch screen to depth of 80.5 ft below LS.
-12	do.	1964	Drl	90	6	--	do.	1,240	r11	6/ 9/64	--	--	T	Log; yield 45 gpm with 5.8 ft of dd (r); 10 ft of 2-inch screen from 78.5 to 88.5 ft below LS.
207-907-1	do.	1963	Drl	98	8	--	Gravel	1,255	15.4	4/30/64	--	--	T	Log; yield 400 gpm with 12 ft of dd; screened.
-2	do.	1963	Drl	90	4, 2	--	Sand and gravel	1,255	3.5	4/30/64	--	--	T	Log; csg 805 ft; 10 ft of screen.
-3	do.	1963	Drl	99	4, 2	--	do.	1,260	19.5	4/30/64	--	--	T	Log; csg 89 ft; 10 ft of screen.
-4	do.	1963	Drl	96	4, 2	--	do.	1,255	16.3	4/30/64	--	--	T	Log; csg 86 ft; 10 ft of screen.
-5	do.	1963	Drl	99	12, 8	--	Gravel	1,260	23.5	4/30/64	--	--	T	Log.
-6	do.	1963	Drl	86	4, ?	--	Sand and gravel	1,250	12.6	4/30/64	--	--	T	Log; screen set to depth of 86 ft below LS.
-7	do.	1963	Drl	92	4, ?	--	do.	1,250	r14	1/17/64	--	--	T De	Log; screen set to depth of 91.5 ft below LS.
-8	do.	1964	Drl	70	4, ?	--	Gravel, sand, clay	1,245	8.4	4/30/64	--	--	T	Log; screen set to depth of 70 ft below LS.
-9	do.	1964	Drl	130	12	--	Sand and gravel	1,240	--	--	--	--	T	Log.
207-908-1	R. Asel	1959	Drl	r66	5	--	Gravel	1,290	--	--	Sw	150	D	Log; iron.
-2	N.Y.S. Dept. Pub. Wks.	1962	Drl	77	3	--	Sand and gravel	1,260	r19.6	7/13/62	--	--	T, De	Log.
-3	U.S. Geological Survey	1962	Drl	99	6	--	do.	b1,252	F19.4	9/ 5/62	--	--	T, O	Log; anal; temp 48.0 10/11/63; yield 30 gpm with 0.15 ft of dd; no. 25 slot well screen from 89 to 99 ft below LS; water-level fluctuations recorded from Sept. 1962 to Jan. 1963.
207-909-1	R. Schrader	--	Drv	r33	1 1/4	--	Sand	1,280	--	--	Sw M	10	D	Seldom used.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
207-909-2	A. Seastedt	a1945	Drl	r312	6	--	Gravel	1,300	--	--	Sw	150	D	
-3	A. Gaeta	--	Drl	r135	6	--	Sand and gravel	1,305	--	--	--	--	D	
-4	H. Clark	--	Drv	r29	1 1/4	--	do.	1,310	--	--	Sw	250	D	
-5	R. Norberg	--	Dug	r10	36	--	Sand	1,255	--	--	Sw	300	D	Anal; iron.
-6	do.	--	Drl	64	5	--	do.	1,260	15.6	11/23/63	--	--	A	Inadequate; appears to be plugged.
-7	do.	b1932	Dug	22	24	--	do.	1,260	18.9	11/23/63	--	--	A	Inadequate.
-8	Unknown	1961	Drl	r271	6, 4	--	do.	1,310	--	--	--	--	D	Temp 51.0 8/15/61; yield 10 gpm.
207-910-1	Harbison-Carborundum Corp.	1958	Drl	181	8	--	Gravel	1,265	--	--	Dw	--	I	Log; anal; temp 48.0 8/26/60; yield 60 gpm (r); finished with slotted casing.
-2	do.	--	Drl	184	10	--	Sand and gravel	1,265	r22	8/25/60	Dw	280,000	I	Log; yield 200 gpm with 16 ft of dd; interference between this well and well 207-910-1.
-3	Village of Falconer	a1945	Drl	r103	6	--	Gravel	1,245	--	--	Sw	--	I	Log; anal; temp 50.0 8/26/60; flowed when drilled; used at sewage treatment plant.
-4	Marlin Rockwell Corp.	1955	Drl	141	10	--	Sand and gravel	1,255	r12	--	Dw	--	I	Log; yield 200 gpm with 20 ft of dd; no. 100 slot well screen, 8 inches in diameter, from 132.5 to 140.5 ft below LS; gravel packed; daily pumpage unknown.
-5	do.	1959	Drl	255	12, 8	r196	Bedrock	1,250	r7	11/ /58	--	--	T, De	Log; gas; yield 3 gpm (b); 12-inch csg 52 ft; 8-inch csg 196 ft.
-6	do.	1959	Drl	15	18	--	Sand	1,250	r7	4/ /60	--	--	T, De	Log; yield 75 gpm with 3.0 ft of dd; installed screen from 9.0 to 14.0 ft below LS.
-7	do.	1960	Drl	r125	12	--	Sand and gravel	1,255	12.7	11/21/60	Dw	--	I	Daily pumpage unknown.
-8	City of Jamestown	--	Drl	r329	--	r329	Gravel	1,240	--	--	--	--	T, De	Log; yield 150,000 gpd from water-bearing zones at 120 to 329 ft below LS; principal aquifer from 100 to 120 ft below LS.
207-911-1	W. Benson	a1930	Drv	11	1 1/4	--	Sand	1,250	4.9	11/12/60	Sw M	--	A	
-2	American Manufacturing Co.	--	Dug	r10	12(ft)	--	Sand and gravel	1,255	--	--	Sw	25,000	I	Anal; water level reported to vary with Chadakoin River level.
207-912-1	T. Pugh	1960	Drl	r113	6	--	do.	1,350	r83	--	--	--	D	Log; yield 25 gpm (r).
-2	J. Nordbusch	a1870	Drl	83	4	--	do.	1,250	18.3	6/15/61	--	--	A	Well once supplied brickyard (now destroyed); may be partly filled.
-3	do.	1948	Drv	69	1 1/4	r70	Sand	b1,263	22.1	6/ 7/63	--	--	A	Equipped with screened drive point.
-4	Knight-Veneer Panel Co.	1937	Drl	43	8	--	Sand and gravel	1,265	p5.7	3/29/62	Sw	8,000	I	Anal; yield 15 gpm (r).
207-913-1	City of Jamestown	--	Drl	r288	6	r240	Bedrock	1,315	--	--	Dw	--	PS	Iron.
207-915-1	City View Dairy	1957	Drl	r111	5	--	Gravel	1,320	--	--	Dw	9,000	I	Log; anal; temp 50.0 8/24/60; yield 13 gpm with 12 ft of dd.
-2	do.	a1941	Drl	r160	6	--	Sand and gravel	1,320	--	--	Dw	9,000	I	
-3	Superior Building Materials	1958	Drl	r80	6	--	Gravel	1,320	--	--	Dw	75	D	Log.
-4	Hollenbeck's Service Station	1959	Drl	r48	6	r48	Gravel, bedrock	1,360	(r)flows	--	Sw	250	C	Log; small amount of gravel reported on top of bedrock.
-5	do.	1960	Drl	r54	7	--	Gravel	1,350	e+1	7/ 5/62	Sw	500	C, PS	Iron; temp 49.0 7/5/62; flows 3 gpm at 0.8 ft above LS.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
207-916-1	Chanticleer Motel	1954	Drl	r50	6	--	Gravel	1,320	--	--	Sw	300	C	Iron.
-2	do.	--	Drl	r56	6	--	do.	1,320	--	--	Sw	200	C	Do.
-3	Fountain Bowl	1959	Drl	r38	8	--	do.	1,325	(r)flows	--	Sw	3,000	C	
207-917-1	E. Lindstrom	1950	Drl	r92	6	--	do.	1,345	--	--	Dw	s5,000	Ir, D	Log; supplies greenhouse.
-2	Fluvanna Elementary School	--	Drl	r40	8	--	do.	1,335	--	--	Dw	8,000	PS	Anal.
-3	Veterans of Foreign Wars	--	Drl	r270	7	--	do.	1,340	--	--	Dw	--	PS	Used intermittently.
207-918-1	F. Poland	1952	Drv	r33	1 1/4	--	Sand and gravel	1,310	--	--	--	300	D	Log; flows in spring; used during summer; finished with screened drive point.
-2	J. Lloyd	--	Drv	r30	1 1/4	--	do.	1,320	r10	--	Sw	150	D	Finished with screened drive point.
-3	W. Fellows	1960	Drv	r30	1 1/4	--	Gravel	1,310	+1.9	7/17/62	--	1,440	C	Temp 50.0 7/17/62; flows less than 1 gpm at 0.5 ft above LS; used to raise bait fish; finished with screened drive point.
-4	do.	1961	Drv	r30	1 1/4	--	do.	1,310	+1.4	7/17/62	--	1,440	C	Temp 50.0 7/17/62; flows 1 gpm at 0.4 ft above LS; used to raise bait fish; finished with screened drive point.
-5	Greenhurst Motel	--	Drl	r38	6	--	Sand and gravel	1,335	r17	--	Dw	200	C	Some sand in water (r).
208-900-1	Village of Randolph	--	Drl	r35	8	--	do.	1,500	flows	--	Dw	290,000	PS	Log; yield 200 gpm; flows (siphon system) at about 200 gpm into reservoir; only pumped when siphon fails; screened.
-3	do.	1962	Drl	r130	8	--	Gravel	1,500	r+6	11/ /62	--	--	PS	Log; well will be added to system when it is screened and finished.
208-904-1	U.S. Geological Survey	1961	Aug	142	3	--	Sand	1,310	--	--	--	--	T, De	Log.
-2	W. Merkiel	1960	Drv	r18	1 1/4	--	Sand and gravel	1,310	r6	--	Sw	150	D	Finished with screened drive point.
-3	F. Obert, Jr.	1959	Drv	r21	1 1/4	--	do.	1,315	r13	--	Sw	150	D	Do.
-4	W. Butman	1959	Drv	r18	1 1/4	--	do.	1,325	r16	--	Sw	100	D	Do.
-5	R. Seekins	1951	Drv	r18	1 1/4	--	do.	1,310	r12	6/ /51	Sw	100	D	Do.
208-905-1	H. Boyd	a1940	Drl	r234	4	--	Gravel, clay	1,320	r40	1940	Dw	1,050	D, F	Log; yield 6 gpm (r); screened; occupant reports "mineral" taste; driller reports bark and twigs at 212 ft below LS.
-2	R. Miller	1951	Drl	r30	4	--	Sand and gravel	1,310	--	--	Dw	150	D	
-3	do.	--	Drv	r22	1 1/4	--	do.	1,310	2.5	9/ 1/61	Sw	500	F	Finished with screened drive point.
-4	E. Dahlgren	--	Drl	r85	7	--	do.	1,310	--	--	Sw	100	D	
-5	G. Maloney	1956	Drl	r66	6	--	do.	1,320	r54	1961	Dw	150	D	Inadequate.
-6	N.Y.S. Dept. Pub. Wks.	1956	Drl	173	2	--	do.	s1,317.3	r35.0	1/ 3/56	--	--	T, De	Log.
-7	B. Bunce	1962	Jet	r200	3	r200	Clay, gravel	1,270	--	--	--	--	A	Log; well may be incompleted.
208-906-1	N.Y.S. Dept. Pub. Wks.	1956	Drl	73	2	r67	Gravel	s1,254.0	r10.1	1/10/56	--	--	T, De	Log.
-2	do.	1956	Drl	98	2	--	Sand	s1,246.4	r7.0	2/ 9/56	--	--	T, De	Do.
-3	R. Sandburg	1960	Drl	r62	5	--	Gravel	1,320	--	--	Dw	150	D	Do.
-4	N.Y.S. Dept. Pub. Wks.	1962	Drl	75	4	--	Sand	s1,246.3	r10.0	7/11/62	--	--	T, De	Do.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
208-906-5	R. Abers	1962	Drl	33	6	--	Sand and gravel	1,275	13.2	9/12/62	Sw	300	D	Yield 3 gpm (r).
-6	A. Wheelock	1940	Drl	r102	5	?	Bedrock	1,295	--	--	Dw	300	D	H_2S.
208-907-1	B. Ornce	--	Drv	r30	1 1/4	--	Sand and gravel	b1,256	--	--	Sw	150	D	Anal; finished with screened drive point.
-2	do.	--	Drv	14	1 1/4	--	do.	b1,256	8.8	8/23/61	--	--	A	Finished with screened drive point; flowed (r) at 3 ft below LS.
-3	C. Nunn	--	Drv	r20	1 1/4	--	do.	b1,259	--	--	Sw	100	D	Finished with screened drive point.
-4	do.	--	Drv	10	1 1/4	--	do.	b1,259	4.8	8/25/61	--	--	D	Finished with screened drive point; used to water lawn less than 10 days per year.
-5	H. Beardsley	--	Drv	r12	1 1/4	--	do.	1,250	(r)flows	--	Sw	200	D	Finished with screened drive point.
-6	N.Y.S. Dept. Pub. Wks.	1955	Drl	75	2	--	do.	s1,270.0	r3.0	12/ 5/55	--	--	T, De	Log.
-7	do.	1955	Drl	70	2	--	Gravel	s1,264.3	r0.0	12/15/55	--	--	T, De	Do.
-8	do.	1962	Drl	78	3	--	Sand and gravel	1,260	r16.9	7/13/61	--	--	T, De	Do.
-9	C. Jarrett	1955	Drv	21	1 1/2, 1	--	Gravel	1,290	16.3	9/13/62	Sw	100	D	
208-909-2	N. Carlson	1962	Drl	82	6	--	do.	1,350	42.2	6/29/62	Dw	150	D	Log; iron.
-3	T. Keith	1950	Drl	r120	6	?	Bedrock	1,310	--	--	Dw	300	D	Supplies two families.
208-910-1	M. Kotar	1952	Drl	r35	6	--	Sand and gravel	1,260	--	--	--	--	D	Flows in the spring.
-2	Gold Star Super Market, Inc.	1955	Drl	r127	8	--	Gravel	1,250	--	--	Dw	--	C	Anal; flowed when drilled; screened.
-3	C. Barton	1932	Drl	r26	3	--	Sand and gravel	1,280	r7	--	Sw	150	D	Inadequate in 1960.
208-911-1	City of Jamestown	1947	Drl	128	18, 12	--	do.	1,250	r5	5/22/47	Dw	720,000	PS	Log; yield 500 gpm with 20.0 ft of dd; screened from 123.8 to 128.8 ft below LS.
-2	P. Hilliker	1923	Drl	60	5	--	do.	b1,285	43.5	6/ 7/63	Dw	100	D	Inadequate.
-3	H. Ball	1947	Drl	r120	6	?	Bedrock	1,295	--	--	--	1,150	D, F	Do.
-4	Unknown	--	Drl	74	3	--	Sand and gravel	s1,248.2	F46.0	10/21/60	--	--	O	Temp 48.6 10/11/62; water-level fluctuations recorded from June 1961 to June 1963.
-5	City of Jamestown	b1920	Drl	r243	10	--	Gravel	1,250	--	--	--	--	De	Log.
-6	S. Zetterman	a1900	Drv	r28	1 1/4	--	Sand and gravel	1,290	--	--	Sw	1,500	D, F	
-7	J. Yannie	1960	Drl	r68	6	r78	do.	1,280	--	--	Sw	250	D	Yield 10 gpm (b); drilled to bedrock at 78 ft below LS, and then pulled casing back to present depth.
-8	U.S. Geological Survey	1961	Aug	33	3	30	do.	1,300	dry	7/20/61	--	--	T, De	Log.
-9	B. Swanson	1962	Drl	39	6, 4	--	Gravel	1,320	21.3	7/ 2/62	--	--	A	Do.
-10	do.	1961	Drl	63	7	--	do.	1,310	28.1	7/ 2/62	--	--	U	Log; well will be used when house is built.
208-912-1	Unknown	--	Drl	r442	8	r442	Sand and gravel	1,250	(r)flowed	--	--	--	T, De	Log; principal water-bearing material was sand on top of bedrock.
-2	City of Jamestown	1947	Drl	131	18, 12	--	do.	1,250	r10	12/16/47	Dw	720,000	PS	Log; anal; yield 500 gpm with 40.5 ft of dd (11/19/62); screened from 125.0 to 130.5 ft below LS; seldom used.
-3	do.	1947	Drl	135	18, 12	--	do.	1,250	r10	5/21/47	Dw	720,000	PS	Log; yield 500 gpm with 32.5 ft of dd (11/19/62); screened from 127.0 to 135.0 ft below LS.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
208-912-4	City of Jamestown	1947	Dri	147	18, 12	--	Sand and gravel	1,250	r18	12/16/47	Dw	720,000	PS	Log; anal; yield 450 gpm with 19.0 ft of dd (11/19/62); screened from 136.5 to 146.5 ft below LS.
-5	do.	1947	Dri	135	18, 12	--	do.	1,250	--	--	Dw	720,000	PS	Log; yield 500 gpm with 21.5 ft of dd (11/20/62); screened from 125.0 to 135.0 ft below LS.
-6	do.	1947	Dri	134	18, 12	--	Sand	1,250	--	--	Dw	720,000	PS	Log; yield 450 gpm with 23.0 ft of dd (6/29/59); screened from 128.8 to 134.0 ft below LS.
-7	do.	1947	Dri	138	18, 12	--	Sand and gravel	1,250	--	--	Dw	--	PS, U	Log; yield 465 gpm with 72.5 ft of dd (8/30/60); screened from 133.0 to 138.0 ft below LS; unused because of low yield.
-8	do.	1956	Dri	143	20, 12	--	do.	s1,251.5	r23	9/13/56	Dw	720,000	PS	Log; yield 700 gpm with 8.0 ft of dd (10/12/62); screened with no. 0.125 slot screen; gravel packed.
-9	do.	1937	Dri	491	12, 6	r486	do.	s1,249.6	--	--	--	--	T, De	Log; anal; screen set from 465 to 486 ft below LS; pumped 50 gpm for 48 hours.
-10	do.	1937	Dri	574	12, 6	r548	do.	s1,249.7	--	--	--	--	T, De	Log; anal; screen set from 500 to 520 ft below LS; yielded 200 gpm.
-11	do.	1947	Dri	137	18, 12	--	Gravel	s1,248.5	r8.6	5/ 7/47	--	--	PS, De	Log; anal; abandoned because of turbidity.
-12	do.	b1920	Dri	r250	10	--	Sand and gravel	1,250	--	--	Dw	720,000	PS	Log; yield 700 gpm with 8.0 ft of dd (10/20/62); slotted casing from about 128 to 149 ft below LS; 105 slots 12 inches by 1/2 inch; area of slots is 913.5 square inches.
-13	do.	b1920	Dri	r240	10	--	do.	s1,250.9	43.0	6/ 7/63	--	--	PS, A	Log; slotted casing from about 131 to 149 ft below LS; area of slots 661.5 square inches.
-14	do.	b1920	Dri	r240	10	--	do.	1,250	58.1	10/21/61	--	--	O	Log; slotted casing from about 133 to 148 ft below LS; water-level fluctuations recorded by the city of Jamestown.
-15	do.	b1920	Dri	r241	10	--	do.	1,250	--	--	--	--	PS, A	Log; slotted casing from about 133 to 148 ft below LS.
-16	do.	b1920	Dri	232	10	--	do.	s1,248.5	F43.0	6/15/63	--	--	O	Log; temp 46.1 10/11/62; water-level fluctuations recorded from Oct. 1953 to present by U.S. Geological Survey; slotted casing from about 130 to 144 ft below LS.
-17	do.	b1920	Dri	r244	10	--	do.	1,250	41.8	6/ 7/63	--	--	O	Log; water level measured weekly by city of Jamestown; slotted casing from about 130 to 145 ft below LS.
-18	do.	b1920	Dri	r242	10	--	do.	1,250	--	--	Dw	720,000	PS	Log; yield 703 gpm with 5.5 ft of dd (11/20/62); slotted casing from about 125 to 145 ft below LS; area of slots is 630.0 square inches.
-19	do.	b1920	Dri	r242	10	--	do.	1,250	31.5	6/ 7/63	--	--	O	Log; water level measured weekly by the city of Jamestown; slotted casing from about 127 to 144 ft below LS.
-20	do.	b1920	Dri	r240	10	--	do.	1,250	--	--	--	--	De	Slotted casing.
-21	do.	--	Dri	r136	10	--	do.	1,250	--	--	--	--	PS, A	Log; anal; yield 520 gpm (r); once pumped for PS by natural discharge and siphon; 10 ft of 8-inch well screen from about 125 to 135 ft below LS.
-22	do.	--	Dri	r138	10	--	do.	1,250	--	--	--	--	PS, A	Log; yield 530 gpm (r); once pumped for PS by natural discharge and siphon; 10 ft of 8-inch well screen from about 121 to 131 ft below LS.
-23	do.	--	Dri	r134	10	--	do.	1,250	--	--	--	--	PS, A	Log; yield 590 gpm (r); once pumped as part of PS by natural discharge and siphon; slotted casing from about 125 to 130 ft below LS.
-24	do.	--	Dri	143	10	--	do.	1,250	57.1	12/ 5/60	--	--	PS, A	Log; yield 450 gpm (r); once pumped as part of PS by natural discharge and siphon; slotted casing from about 132 to 143 ft below LS.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
208-912-25	City of Jamestown	--	Drl	137	10	--	Sand and gravel	1,250	56.7	12/ 5/60	--	--	PS, A	Log; yield 610 gpm (r); once pumped as part of PS by natural discharge and siphon; slotted casing from about 127 to 137 ft below LS.
-26	do.	--	Drl	r125	10	--	do.	1,250	--	--	--	--	PS, A	Log; yield 575 gpm (r); once pumped as part of PS by natural discharge and siphon; slotted casing from about 113 to 124 ft below LS.
-27	do.	--	Drl	r133	10	--	do.	1,250	--	--	--	--	PS, A	Log; yield 660 gpm (r); once pumped as part of PS by natural discharge and siphon; slotted casing from about 120 to 130 ft below LS.
-28	do.	--	Drl	r137	10	--	do.	1,250	--	--	--	--	PS, A	Log; yield 625 gpm (r); once pumped as part of PS by natural discharge and siphon; slotted casing from about 125 to 135 ft below LS.
-29	do.	--	Drl	r140	10	--	do.	1,250	--	--	--	--	PS, A	Log; yield 620 gpm (r); once pumped as part of PS by natural discharge and siphon; slotted casing from about 126 to 137 ft below LS.
-31	S. Pantell	1960	Drl	55	6	r35	Bedrock	1,300	16.7	12/ 2/60	--	--	U	Log; well will be put into use.
-32	J. Thompson	--	Drl	r105	6	--	Sand and gravel?	1,285	--	--	Dw	--	C	Well may end in bedrock.
-33	City of Jamestown	1937	Drl	566	12, 8. 6	r565	Gravel	1,250	--	--	--	--	T, De	Log; screen set from 532 to 562 ft below LS; yield 200 gpm (r).
208-914-1	Amsco Excal Metal Co.	1960	Drl	r210	8	r17	Bedrock	1,730	r70	--	Dw	30,000	I	
-2	do.	--	Drl	r202	8	r17	do.	1,730	--	--	Dw	30,000	I	Yield 30 gpm (r) with pumping level at 120 ft below LS.
-3	City of Jamestown	1936	Drl	r102	5	a25	do.	1,730	--	--	Dw	30,000	I	Log; inedequate during heavy demand; used by Amsco Excal Metal Co.
208-921-1	J. Schaftnaer	1962	Drl	r77	6	r15	do.	1,390	r30	7/13/62	--	--	U	Log; yield 4 gpm (b); casing to 20 ft below LS; will be used by new house being built.
208-922-2	M. Anderson	--	Drv	r90	2	--	Sand and gravel	1,310	flows	7/17/62	Sw	s150	D	
209-900-1	L. Lewis	1947	Drv	r44	1 1/4	--	do.	1,390	r14	--	Sw	150	D	Iron.
209-901-1	G. Brown	a1942	Drl	r95	6	r90	Bedrock	1,395	r20	1960	Dw	4,050	D, F	Iron; supplies four families; probably derives much water from sand and gravel on top of bedrock.
209-902-1	D. Beaver	--	Drl	r100	6	?	do.	1,360	--	--	Dw	150	D	
-2	J. Patterson	1957	Drl	72	6	a19	do.	1,390	17.4	9/ 5/62	Dw	100	D	Csg 19 ft.
209-903-2	J. Aiken	a1950	Drl	r115	6	?	do.	1,390	--	--	Dw	550	D	
-3	N.Y.S. Dept. Pub. Wks.	1962	Drl	75	2	--	Sand and gravel	1,420	--	--	--	--	T, De	Log.
209-905-1	Kennedy Central School	1956	Drl	r80	8	--	do.	1,320	--	--	Dw	1,600	In	Log; alkalinity 113.0 ppm; iron 0.08 ppm; ph 7.8; yield 30 gpm (b).
-2	U.S. Geological Survey	1961	Aug	142	3	--	Silt, sand	1,275	--	--	--	--	T, De	Log.
-3	S. Crawford	--	Drl	r92	6	--	Gravel	1,330	r78	--	Dw	300	D, F	
-4	D. Clark	1958	Drl	84	7	--	Sand and gravel	1,320	71.4	9/ 1/61	Dw	200	D	Log.
-5	G. Anderson	1958	Drl	r56	5	--	Gravel	1,270	--	--	Dw	100	D	Do.
-6	R. Ormond	a1946	Drl	r36	6	--	Sand and gravel	1,270	--	--	Dw	450	D	
-7	N. Lincoln	1930	Drl	r90	4	--	do.	1,320	--	--	Dw	200	D	

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
209-906-3	North Side Water Co.	a1923	Drl	r85	6	--	Sand and gravel	1,300	--	--	Dw	s2,800	PS	Auxiliary use only.
-4	V. Eccles	1923	Drl	r80	5	--	do.	1,260	--	--	Dw	100	D	
-5	D. Maloney	1944	Drl	r76	6	--	do.	1,315	r40	--	Dw	400	D	Supplies two houses.
-6	U.S. Geological Survey	1962	Drl	175	6	170	Bedrock	1,250	+22.3	8/27/62	--	--	T, O	Log; anal; temp 54.0 8/27/62; H_2S; iron; csg 170 ft.
209-911-1	L. Becker	1952	Drl	r55	6	r17	do.	1,305	r5	--	Sw	--	D	Anal; csg 18 ft.
209-912-1	Sunnyside Cemetery	--	Drv	25	1 1/4	--	Sand and gravel	1,305	dry	11/22/60	Sw M	--	In	Inadequate; finisheo with screened drive point.
209-913-1	P. Rounds	a1915	Drl	129	8	--	do.	s1,255.9	F16.5	8/30/60	--	--	O	Anal; temp 48.9 10/11/62; water level measured weekly by city of Jamestown; water-level fluctuations recorded by U.S. Geological Survey from June 1961 to June 1963.
-2	F. Engstrom	a1925	Drv	r137	2 1/2	--	do.	1,260	--	--	Sw	s200 w600	D, F	
-3	A. Birath	a1940	Drl	r120	6	--	do.	1,275	--	--	Dw	50	D	
-4	G. Burkland	b1920	Drv	23	1 1/4	--	do.	1,285	20.4	9/15/60	--	--	A	Inadequate during summer; finished with screened drive point.
-5	C. Lindahl	--	Drl	r125	--	--	do.	1,250	--	--	Sw	200	D	
-6	do.	--	Drl	100	3	--	do.	1,250	28.0	10/12/60	--	--	A	
-7	F. Thompson	--	Drl	r145	5	--	do.	1,270	--	--	Sw	650	D, F	
-8	H. Cederblad	b1925	Drl	127	5	--	do.	b1,264	31.0	11/10/60	Dw	1,150	D, F	
-9	Church of God	1957	Drv	r39	1 1/2	--	Sand	1,295	--	--	Sw	--	In	Log; used intermittently.
-10	E. Davison	1956	Drl	r34	6	--	Sand and gravel	1,290	--	--	Dw	450	D	Supplies two families.
-11	U.S. Geological Survey	1961	Aug	102	3	--	do.	1,290	17.6	6/26/61	--	--	T, De	Log.
-12	do.	1962	Drl	55	6	--	do.	b1,286	F18.8	8/17/62	--	--	T, O	Log; temp 44.8 10/12/62; yield 4 gpm with 8.8 ft of dd; water-level fluctuations recorded by U.S. Geological Survey from Sept. 1962 to Jan. 1963.
209-915-1	Producto Machine Co.	1961	Drl	r400	8	r10	Bedrock	1,710	r25	1961	Dw	1,500	In	Inadequate: csg 12 ft.
-2	do.	--	Drl	r100	16	a12	do.	1,700	--	--	Dw	0	U	Do.
-3	do.	1962	Drl	r100	7	r12	do.	1,690	r3	1962	Dw	0	U	Yield 18 gpm (r); csg 12 ft; will be used when system is completed.
209-922-1	D. Soules	1960	Drl	r50	5	r20	do.	1,340	r5	9/ 7/60	Dw	200	D	H_2S; yield 27 gpm (b) csg 22 ft.
-2	R. Keefer	1961	Drl	r196	6	--	Sand and gravel	1,320	+9.1	7/11/62	Sw	150	D	Anal; temp 54.0 7/11/62; H_2S; flow 2 gpm at 1.7 ft above LS.
-3	R. Daigler	--	Drl	87	4	--	Gravel	1,310	flows	7/17/62	Sw	300	D	Temp 53.5 7/17/62; flow less than 1 gpm at 0.2 ft above LS.
-4	E. Schaefer	1961	Drl	r90	7	--	do.	1,310	flows	7/16/62	Sw	100	D	Log; temp 50.5 7/17/62; yield 4 gpm (b) with 45 ft of dd; flows less than 1 gpm at 0.3 ft above LS.
209-923-1	D. Carlson	b1925	Drv	r25	--	--	Sand and gravel	1,320	flows	9/ 7/60	--	43,000	In	Anal; temp 50.2 9/7/60; flows 30 gpm at LS; used for raising fish.
-2	C. Young	--	Drv	r102	1 1/4	--	do.	1,325	r3	9/ 7/60	Sw	--	D	
-3	Chautauqua County Highway Dept.	1959	Aug	100	--	--	Silt, sand	1,315	r4	4/24/59	--	--	T, De	Log; well flowed in material found at 93 ft below LS.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
209-923-4	Cheutauqua County Highway Dept.	1959	Aug	122	--	--	Sand and gravel	1,310	(r)flowed	--	--	--	T, De	Log; well flowed in material found at 88 ft below LS.
-5	J. Lipsy	1960	Drl	36	6	--	do.	1,345	32.2	9/ 7/60	Dw	--	D	Log; yield 2 gpm (r).
-6	D. Carlson	1936	Drl	r400	6	--	do.	1,340	r8	1936	Dw	600	D	Yield 300 gpm with 10.0 ft of dd (r).
-8	Wight Real Estate	1962	Drl	r250	6, 4	--	Sand	1,375	39.9	7/12/62	Dw	--	U	Log; well will be used when finished.
-9	R. Smith	1962	Drv	r30	1 1/4	--	do.	1,310	+2.5	7/11/62	--	2,880	C	Anal; temp 49.5 7/11/62; flows 2.0 gpm at 2.0 ft above LS; used to raise bait fish; finished with screened drive point.
-10	do.	1959	Drv	r30	1 1/4	--	do.	1,310	+1.6	7/11/62	--	1,440	C	Temp 49.5 7/11/62; flows less then 1.0 gpm at 1.4 ft above LS; used to raise bait fish; finished with screened drive point.
-11	P. Smith	1948	Drl	r203	6	--	Gravel	1,310	+3.3	7/19/62	Sw	s300	D	Anal; flows 1/2 gpm at 2.3 ft above LS; yield 60 gpm (r).
209-924-1	W. Saxon	b1910	Drv	r18	1 1/2	--	Sand and grevel	1,320	flows	8/10/60	--	--	A	Anal; temp 48.5 8/11/60; flows 12 gpm at 1.0 ft above LS.
-2	do.	a1935	Drl	r96	--	--	do.	1,325	--	--	Sw	100	D	
-3	W. Lee Bull, Inc.	a1947	Drl	r64	6	--	Sand	1,330	r15	9/22/60	Dw	--	D	Log; anal; temp 50.0 9/22/60; H_2S; yield 5 gpm (r).
-4	Chautauqua County Highway Dept.	1959	Aug	90	--	--	Clay, gravel	1,310	r4	4/24/59	--	--	T, De	Log.
-5	Unknown	1962	Drl	30	7	--	Sand	1,310	flows	7/12/62	--	--	U	Anal; temp 49.0 7/12/62; flows 3 gpm at 2.2 ft above LS; drilled on date visited.
-6	F. Waldy	1925	Drv	r30	3/4	--	Sand and gravel	1,315	+1.2	7/19/62	Sw	100	D	Temp 50.0 7/19/62; flows less than 1/2 gpm at 1.2 ft above LS.
-7	W. Smith	1961	Drl	r257	7, 3	a245	Bedrock?	1,315	flows	7/19/62	Sw	--	U	Flows less than 1/4 gpm at LS.
-8	Melody Restaurant	1960	Drv	r29	1 1/4	--	Gravel	1,320	+3.0	7/16/62	Sw	500	C	Temp 49.0 7/16/62; flows 2 1/2 gpm at 5.0 ft below LS; finished with screened drive point.
-9	R. Marsh	1934	Drl	r114	6	r98	Bedrock	1,330	r10	9/ /60	Sw	200	D	Csg 98 ft (r).
209-925-1	D. Connelly	1912	Drl	r113	4	r100	do.	1,380	r29	--	Dw	200	D	H_2S; csg 100 ft (r).
209-926-1	W. Findley, Jr.	1957	Drl	r98	6	r90	do.	1,400	r19	--	Dw	400	D, F	Csg 90 ft (r).
210-900-2	L. Archer	1960	Drl	r200	6	r5	do.	1,370	r10	--	Dw	1,200	D, F	Yield 2 1/2 gpm (b); driller reported to have hit oil at 225 ft below LS, and well was backfilled to 200 ft;
210-901-1	B. McElwain	--	Dug	14	36	r14	Till	1,325	13.4	9/ 4/62	Sw M	20	F	Inadequate; bedrock at bottom of well (r).
210-902-1	U.S. Geological Survey	1961	Aug	94	3	--	Sand	1,380	--	--	--	--	T, De	Log; principal water-bearing zone at 79 to 93 ft below LS.
-2	do.	1961	Aug	43	3	--	Gravel	1,285	3.3	7/14/61	--	--	T, De	Log; principal water-bearing zone at 28 to 30 ft below LS.
-3	C. Teriwillinger	b1900	Drl	r40	4	--	Sand	1,375	r20	--	Sw	--	D	Temp 47.6 9/5/62; yield 5 gpm (r).
-4	A. Bloomquist	a1935	Drl	40	5	--	do.	1,315	32.2	9/ 5/62	Dw	--	D	
210-903-1	U.S. Geological Survey	1961	Aug	85	3	--	Gravel	1,280	6.7	7/14/61	--	--	T, De	Log; principal water-bearing zone from 0 to 46 ft below LS.
-2	R. Shields	1960	Drv	22	1 1/4	--	Sand and gravel	1,270	r10	--	Sw	2,000	F	Finished with screened drive point.
210-904-1	B. Johnson	--	Dug	r22	36	--	Till	1,340	r19	8/ /62	Sw	350	D	Inadequate.
-2	H. Lindquist	a1930	Drl	r140	5	?	Sand and gravel?	1,435	--	--	Dw	1,600	D, F	
210-905-1	C. Anderson	1959	Drl	r85	7	--	Gravel	1,300	r45	6/ /59	Dw	250	D	

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
210-905-2	C. Anderson	1959	Drl	r61	7	--	Gravel	1,300	r27	8/ /59	Dw	2,000	F	Supplies 100 cows.
210-912-1	W. Ross	a1900	Drl	79	5	?	Bedrock	1,315	27.3	11/22/60	Dw	100	D	Anal; temp 48.5 11/22/60.
-2	U.S. Geological Survey	1962	Drl	67	6	71	Sand and gravel	b1,305	F42.4	8/29/62	--	--	T, O	Log; temp 54.3 10/12/60; finished with 2-inch diameter screened drive point; water-level fluctuations recorded by the U.S. Geological Survey from Sept. 1962 to Jan. 1963.
210-913-1	E. Holmquist	a1880	Drl	r132	6	?	Bedrock	1,335	r40	9/15/60	Dw	150	D	H_2S.
-2	do.	a1885	Drl	r1,820	6	?	do.	1,355	(r)flowed	--	--	--	A	Gas; csg 200 ft (r); this well was formerly used as a gas well; principal water-bearing zone was in bedrock at about 200 ft below LS.
-4	do.	--	Drv	35	1 1/4	--	Sand and gravel	1,295	19.1	12/ 9/60	Sw M	30	D	Finished with screened drive point.
210-915-1	A. and E. Mangine	a1926	Drl, Jet	r240	4 1/2, 3	r571	do.	1,250	+16.9	6/ 7/63	Sw	--	C	Anal; temp 53.2 8/23/60; H_2S; yield 75 gpm (r); driller reports that well was drilled to rock and then casing was pulled back to 240 ft below LS; flows 12 gpm at 4.5 ft above LS.
-2	do.	1952	Drl	r138	7	--	do.	b1,250	+9.1	6/ 7/63	--	--	C	Log; anal; temp 55.0 6/15/61; yield 50 gpm with 31.0 ft of dd; flows 5 gpm at 3.7 ft above LS; used only in spring.
-4	K. Asel	--	Drl	r125	7	--	do.	1,280	--	--	Sw	250	D, C	
-5	R. Heath	--	Drl	r980	8	r90	Bedrock	1,300	--	--	--	--	G	Used intermittently; principal water-bearing zone in bedrock at 110 ft below LS.
-6	W. Wagner	1952	Drl	r72	6	--	Sand and gravel	1,300	--	--	Dw	300	C	
-7	H. Pearson	--	Drl	r100	7	r30	Bedrock	1,310	--	--	Dw	800	C	H_2S.
-8	R. Heath	1927	Drl	r80	5	--	Sand and gravel	1,300	r14	--	Sw	100	D	Anal.
-9	R. Overturf	--	Drl	79	7	--	do.	1,295	39.3	11/ 8/60	Dw	300	C	
-10	M. Plaster	--	Drl	122	7	--	do.	b1,274	23.7	11/ 8/60	Dw	150	D	Iron.
-11	C. Batterson	1955	Drl	r104	7	--	do.	1,275	23.0	11/ 8/60	Dw	100	D	Anal.
-12	N.Y.S. Dept. Pub. Wks.	1959	Drl	127	3	--	Silt	s1,257.4	r10.2	6/ 4/59	--	--	T, De	Log.
-13	do.	1959	Drl	62	3	--	do.	s1,254.7	r11.0	9/28/59	--	--	T, De	Do.
210-922-1	P. Torsell	1959	Drl	r45	7	r40	Bedrock	1,355	--	--	--	--	D	Yield 27 gpm (r).
210-925-1	Woodlawn Water District	1954	Drl	r61	6	--	Gravel	1,315	r4	--	Sw	s5,000	PS	Yield 60 gpm (r); csg 60 ft; perforated casing; used summers.
210-926-1	H. Swanson	1940	Drv	r20	1 1/4	--	Sand and gravel	1,310	--	--	Sw	s200	D	Finished with screened drive point.
-2	Camp Timber Top	1952	Drl	r156	6	r112	Bedrock	1,330	--	--	--	--	C	Log; yield 1 1/2 gpm (b); csg 112 ft.
-3	A. Chase	1922	Drl	62	6	r18	do.	1,390	+0.7	11/30/62	Dw	w100 s300	D	Csg 18 ft.
-4	P. Danelson	1940	Drv	r42	1 1/2	--	Gravel	1,320	r14	1958	Sw	270	D, F	
211-900-1	G. Cretacca	1961	Drv	r15	1 1/4	--	Sand	1,260	--	--	Sw M	--	D	Used intermittently.
211-901-1	Unknown	--	Drl	46	6	--	Sand and gravel	1,260	+2.0	8/26/61	--	--	D	Anal; temp 52.0 8/26/61; H_2S; flows less than 1 gpm at 1.0 ft above LS; used for drinking.
211-902-1	H. Spaulding	--	Drl	r112	5	--	do.	1,345	r15	--	Dw	500	D, F	

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
211-903-1	D. Schulz	--	Drl	--	4 1/2	--	Bedrock	1,500	p34.7	9/ 6/62	Dw	1,100	D, F	Inadequate during summers of 1961-62.
-2	A. Shannon	a1920	Drl	r85	4 1/2	--	do.	1,480	--	--	Sw	150	D, F	
-3	C. Hotchkiss	--	Drl	r177	6, 5	--	do.	1,390	r64	--	Dw	1,000	D, F	
-4	F. Schulz	1957	Drl	r143	6, 4	--	Gravel	1,420	--	--	Dw	750	D, F	
-5	do.	--	Drl	145	5	--	do.	1,420	41.8	9/ 7/62	--	0	A	Inadequate.
-6	C. Morris	1961	Drl	r55	6	--	do.	1,415	--	--	Dw	900	D, F	Log.
-7	C. Mason	1954	Drl	r60	4	r24	Bedrock	1,490	r20	1954	Dw	200	D	
211-905-1	T. Anderson	1956	Drl	r140	7	r35	do.	1,535	r120	--	Dw	250	D	Inadequate during summer of 1962; yield 5 gpm (r).
211-914-1	H. Bowers	1960	Drl	38	5	?	do.	1,350	14.7	9/12/60	Sw M	0	U	H_2S.
-2	Cassadaga Valley Central School	1955	Drl	r100	--	?	Bedrock?	1,315	36.5	9/15/60	Dw	4,000	In	Do.
-3	Gerry Homes, Inc.	--	Drl	111	6	--	Bedrock	1,325	34.5	11/ 8/60	Dw	100	D	H_2S; iron.
-4	R. Johnson	--	Drl	94	6	--	do.	1,305	23.2	11/ 8/60	--	--	A	
-5	J. Anderson	--	Drl	40	6	--	Sand and gravel?	1,315	24.4	11/15/60	Dw	150	D	
-6	C. Hitchcock	1928	Drl	43	6	r38	Bedrock	1,315	23.8	11/15/60	Sw	150	D	
211-915-1	R. Dawley	a1957	Drl	358	6	r368	Gravel?	1,265	+4.0	8/11/60	--	--	A	Log; anal; iron; temp 56.0 4/3/62; flows less than 1 gpm at 3.1 ft above LS; driller reports water-bearing zone is gravel on top of bedrock.
-2	N. Johnson	b1920	Drv	r20	1 1/2	--	Sand and gravel	1,270	--	--	Sw	150	D	
-3	M. Thompson	1912	Drl	r356	6	--	do.	1,260	flows	9/ 9/60	--	--	A	Log; anal; flows 3 gpm at 1.0 ft above LS; former gas test well; principal water-bearing zone from 123 to 160 ft below LS.
-5	do.	1959	Drl	r35	5	--	do.	1,285	r18	1959	Sw	3,250	D, F	Log.
-6	Gerry Homes, Inc.	--	Drl	r70	6	?	Bedrock	1,330	--	--	Sw	5,000	In	H_2S.
-9	do.	1950	Drl	r3,700	7	?	do.	1,330	--	--	--	--	G	Supplies gas for cooking.
-10	Free Methodist Church	1931	Drl	r40	6	--	Sand and gravel	1,300	--	--	Sw	--	In	Used intermittently.
-11	G. Stanford	1959	Jet	r79	1 1/2	--	Gravel	1,260	flows	11/28/60	Sw	900	F	Log; H_2S; flows 1 gpm at 1.5 ft above LS.
-13	G. Pelton	--	Drv	19	1 1/4	--	Sand and gravel	1,275	11.6	11/28/60	--	--	U	Finished with screened drive point.
-15	U.S. Geological Survey	1961	Aug	142	3	--	Sand	1,285	10.2	6/29/61	--	--	T, De	Log.
-16	do.	1961	Aug	73	1 1/4	--	do.	b1,272	F9.6	7/27/61	--	--	T, O	Log; temp 48.5 10/12/62; finished with screened drive point.
211-916-1	N. Blood	a1930	Drl	r95	6	a25	Bedrock	1,305	--	--	Dw	550	D	Anal.
-2	A. Carlson	1949	Drl	r160	6	r20	do.	1,300	--	--	Dw	200	D	Salty; inadequate; csg 20 ft.
-3	do.	--	Drv	19	1 1/4	--	Sand	1,280	15.6	10/ 7/60	--	--	A	Inadequate; finished with screened drive point.
-4	I. Sischo	1954	Dug	r4	24	--	do.	1,260	3.6	10/ 7/60	--	250	D	
211-924-1	Unknown	1962	Drl	r75	6	r38	Bedrock	1,340	28.3	7/10/62	--	--	D	Log; yield 6 gpm (b); well not in use as of 7/10/62; csg 42 ft.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
211-924-2	L. McKean	1962	Dri	r130	6	r20	Bedrock	1,370	24.0	7/13/62	--	--	D	Log; yield 1 gpm (b); well not in use as of 7/13/62; csg 28 ft.
211-926-1	N.Y.S. Conservation Dept.	1956	Jet	r108	1 1/4	--	Gravel	1,310	+4.6	9/30/60	--	--	PS	Log; anal; temp 49.8 9/22/60; flows 10 gpm at 1.0 ft above LS; used intermittently; finished with screened drive point.
-2	do.	1952	Drv	r28	1 1/4	--	Sand and gravel	1,310	+1.9	9/30/60	--	--	U	Anal; temp 52.0 9/30/60; flows 4 gpm at 1.3 ft below LS; finished with screened drive point.
-3	do.	1952	Jet	r110	--	--	Gravel	1,310	(r)flowed	--	Sw	--	In	
-4	Prendergast Point Assoc.	1952	Dri	r107	6	--	Sand and gravel	1,315	(r)flows	--	Sw	s10,000	PS	Log; anal; finished with perforated casing; used approximately 6 months per year; yield 50 gpm (r).
211-927-1	N.Y.S. Dept. Pub. Wks.	1961	Dri	107	2	--	Gravel	s1,314.7	r8.5	1/ 5/61	--	--	T, De	Log; flowed 10 gpm at LS from a water-bearing zone in gravel at 29 ft below LS (r).
-2	do.	1961	Dri	52	2	--	Sand	s1,318.1	r6.5	1/20/61	--	--	T, De	Log; sand flowed into casing at 39 ft below LS.
-3	C. Jones	1947	Drv	r39	2, 1 1/4	--	do.	1,330	r15	1947	Sw	250	D	
-4	J. Wester	1952	Dug	18	24	--	Sand and gravel	1,330	14.4	11/28/62	Sw	150	D	Owner reports sand and gravel from 15 to 18 ft below LS.
-5	G. Clark	1916	Drv	r31	1 1/4	--	do.	1,330	flows	--	Sw	250	D	Flows greater than 10 gpm (r) at 1.5 ft below LS; another well on property flows greater than 10 gpm at 1.0 ft above LS.
212-900-3	M. Howard	--	Dri	r100	6	--	do.	1,290	flows	9/ 7/61	Dw	0	U	Iron; flows less than 1 gpm at LS.
212-901-1	E. Marshall	1961	Jet	r130	2	--	Sand	1,260	+4.5	8/28/61	--	--	De	Log; inadequate (became plugged with sand).
-2	E. Maslakowski	--	Dri	r184	3	--	Gravel	1,260	+9.5	8/28/61	--	100+	D	Anal; temp 51.0 8/28/61; H_2S; flows 3 gpm at 2.0 ft above LS; used for drinking water by several camps.
-3	L. Allen	1938	Dri	r130	--	--	Sand and gravel	1,260	flows	8/28/61	--	--	D	Anal; temp 52.0 8/28/61.
-4	W. Williams	1960	Jet	r122	3/4	--	do.	1,260	+8.0	8/28/61	--	--	D	Anal; temp 51.0 8/28/61; flows less then 1 gpm at 1.5 ft above LS; used approximately 150 days per year; driller reports wood, nuts, and pine cones brought up while jetting well.
-5	Unknown	--	Jet	r124	2	--	do.	1,260	flows	8/28/61	--	--	A	Temp 52.0 8/28/61; flows less than 1 gpm at 1.6 ft above LS; well reported to have had much greater flow.
-6	J. Spence	1951	Jet	r125	2	--	do.	1,260	flows	8/31/61	Sw	--	D	
-7	E. Marshall	1961	Jet	r421	7, 2	--	Sand	1,260	+3.0	10/31/61	--	--	U	Log; flows less than 1 gpm at 2.0 ft above LS; not in use as of 10/31/61; pieces of wood and organic material washed up during construction.
-8	G. Myers	--	Jet, Dri	r347	5	r312	Bedrock	1,290	r12	1958	Dw	900	D, F	Log; H_2S; driller reports wood and nuts at about 200 ft below LS.
212-902-1	B. Bush and F. Eldridge	1954	Jet	r160	2	a180	Sand and gravel	1,270	flows	8/12/60	--	--	F	Anal; temp 48.8 8/12/60; flows 2 gpm at 2.0 ft above LS; driller reports bedrock at 180 below LS in nearby test hole.
-2	do.	a1930	Jet	r124	3	--	do.	1,270	flows	8/12/60	--	--	Ir	Anal; temp 48.0 8/17/60; H_2S; flows 15 gpm at about LS.
212-903-1	U.S. Geological Survey	1961	Aug	96	3	?	Sand	1,300	6.0	6/28/61	--	--	T, De	Log.
-2	J. and R. Johnson	--	Dri	77	4	--	Sand and gravel	1,305	8.2	9/ 6/62	Dw	400	D	H_2S.
-3	M. Dye	1957	Dri	66	6	--	Sand and gravel?	1,360	16.6	9/ 6/62	Sw	300	D	
212-904-1	I. Rubel	--	Drv	r20	--	--	Sand and gravel	1,320	--	--	Dw	150	D	

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
212-904-2	I. Rubel	--	Drv	r30	1 1/4	--	Sand and gravel	1,320	r6	--	Sw M	--	D	Used occasionally; finished with screened drive point.
-3	do.	--	Drv	r20	1 1/4	--	do.	1,320	r6	--	Sw M	--	U	Finished with screened drive point.
-4	A. Yannie	1950	Drv	r15	1 1/4	--	do.	1,320	r10	--	Sw	100	D	Do.
212-905-1	J. Turizillo, Jr.	1960	Drv	r23	1 1/4	--	do.	1,320	r10	--	Sw	200	D	Do.
-2	W. Williams	--	Drv	r22	1 1/4	--	do.	1,340	--	--	Sw	150	D	Do.
-3	do.	--	Drv	23	1 1/4	--	do.	1,340	14.5	8/28/61	Sw M	--	U	Do.
212-906-1	Ellington Elementary School	--	Drl	r236	7	r185	Bedrock	1,375	--	--	Dw	1,500	In	Anal; iron.
212-914-1	C. Johnson	--	Drv	r25	1 1/4	--	Sand and gravel	1,410	--	--	Sw	--	D	Finished with screened drive point.
212-915-1	R. Lown	a1925	Drl	r92	6	?	Bedrock	1,330	--	--	Dw	300	D	H_2S.
-2	do.	a1910	Drl	r65	5	--	Sand and gravel	1,315	--	--	Dw	1,200	D, F	
212-916-1	U.S. Geological Survey	1962	Drl	173	6	--	do.	b1,262	+21.4	6/ 7/63	--	--	T, O	Log; anal; temp 51.0 8/23/62; H_2S; flows 4 gpm at 4.6 ft above LS.
212-917-1	M. and J. Palermo	1940	Drl	r54	6	--	do.	1,295	r19	--	Sw	500	C	
-2	B. Faulkner	b1948	Drv	r16	1 1/4	--	Gravel	1,295	--	--	Sw	200	F	Used intermittently; finished with screened drive point.
-3	D. Crandall	1950	Drv	r27	1 1/4	--	do.	1,295	--	--	Sw	250	D	Well flowed when driven (r); finished with screened drive point.
-4	E. Heath	a1936	Drv	r30	1 1/4	--	Sand and gravel	1,305	--	--	Sw	200	D	Finished with screened drive point.
-6	E. Nickerson	--	Drv	r32	1 1/4	--	do.	1,305	--	--	Sw	1,500	D, F	Do.
-7	B. Edwards	--	Drl	71	7	?	Bedrock	1,320	9.0	11/18/60	Sw	--	D	
-8	U.S. Geological Survey	1961	Aug	102	3	--	Sand	1,270	5.0	7/25/61	--	--	T, De	Log; water-bearing zone from 7 to 15 ft below LS.
213-901-1	E. Morrison	--	Drl	r190	3	--	Gravel	1,270	+10.0	8/10/61	--	1,000	D, F	Anal; temp 53.0 8/10/61; H_2S; flows 8 gpm at 2.0 ft above LS.
-2	M. Booth	--	Drv	r20	1 1/4	--	Sand and gravel	1,280	--	--	Sw	200	D	Finished with screened drive point.
-3	F. Wright, Jr.	--	Drl	58	6	--	do.	1,300	18.7	9/ 9/61	Dw	200	D	
213-902-1	J. Mason	1900	Drl	r200	4	--	Gravel	1,270	+11.1	8/ 4/61	--	150	D	Anal; temp 53.0 8/4/61; H_2S; flows 6 gpm at 1.6 ft above LS.
-2	do.	1900	Drl	r156	4	--	do.	1,270	+21.6	8/ 4/61	--	--	D, F	Anal; temp 51.0 8/4/61; H_2S; flows 20 gpm at 3.6 ft above LS; supplies house and barn.
-3	H. Rhoades	1905	Jet	r92	3	--	do.	1,270	flows	8/15/61	--	1,000+	D, F	Log; temp 54.0 8/15/61; flows 5 gpm; supplies two houses and barn.
-4	do.	--	Jet	r104	4	--	do.	1,270	+17.3	8/15/61	--	--	F	Anal; temp 50.0 8/15/61; flows 8 gpm at 1.8 ft above LS.
213-903-1	W. Congdon	--	Drv	r21	1 1/4	--	Sand and gravel	1,290	--	--	Sw	350	D	Finished with screened drive point.
-2	A. Boyd	--	Drv	r22	1 1/4	--	do.	1,290	r5	--	Sw	200	D	Log; finished with screened drive point.
-3	E. Bently	a1920	Drv	r25	1 1/4	--	do.	1,290	--	--	Sw	500	D, F	Finished with screened drive point.
-4	G. Mason	--	Drv	r20	1 1/2	--	do.	1,300	r9	--	Sw	300	D	Do.
-5	R. Beckstrom	--	Drl	167	7	--	do.	1,290	6.2	9/ 5/61	Sw	250	D	H_2S.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
213-903-6	G. Swanson	--	Drv	42	1 1/4	--	Sand and gravel	1,280	0.2	9/ 5/61	--	1,440	F	Anal; temp 49.0 9/5/61; flows 1 gpm at 1.0 ft below LS; used for cooling purposes; finished with screened drive point.
-7	do.	--	Drv	r40	1 1/4	--	do.	1,280	r2	--	Sw	600	D, F	Finished with screened drive point.
213-904-1	R. Birch	1955	Drv	r18	1 1/4	--	Gravel	1,310	e3.5	8/10/61	Sw	150	D	Log; anal; finished with screened drive point.
-2	C. Smith	--	Drl	r100	3	--	Sand and gravel	1,310	+1.5	8/10/61	Sw	300	F	Anal; temp 50.0 8/10/61; flows 0.5 gpm at 0.5 ft above LS (does not flow during summer); used for cooling purposes.
-3	do.	--	Drv	r20	1 1/4	--	Gravel	1,310	--	--	Sw	600	F	Finished with screened drive point.
213-905-1	L. Greely	1958	Drv	r27	1 1/4	--	Sand	1,350	r20	9/ 1/60	Sw	100	D	Log; finished with screened drive point.
-2	do.	--	Drv	r39	1 1/4	--	Sand and gravel	1,350	r17	9/ /60	Sw M	--	U	Finished with screened drive point.
213-906-1	H. Walker	--	Drv	r40	1 1/4	--	do.	1,360	r11	--	Sw	200	D	Inadequate during summer 1960; finished with screened drive point.
213-915-1	F. Ball	--	Drv	r21	1 1/4	--	Sand	1,330	--	--	Sw	300	D, C	Finished with screened drive point.
-2	Spartan Tool Co.	a1953	Drv	r18	1 1/4	--	do.	1,300	--	--	Sw	300	D	Do.
-3	G. Larson	1948	Drl	r670	8, 6	r55	Bedrock	1,315	--	--	--	--	G	Csg 444 ft.
213-917-1	A. Segerlin	1947	Drl	r740	8, 4	a10	do.	1,285	--	--	--	--	G	Deepened to 740 ft below LS on 11/12/58.
-2	do.	--	Drl	--	6	a10	do.	1,280	--	--	Sw	300	D	Iron; flows during winter (r).
-3	N.Y.S. Dept. Pub. Wks.	1961	Drl	114	2	--	Sand	1,265	r8	8/ 9/61	--	--	T, De	Log; principal water-bearing zone from 8 to 14 ft below LS.
-4	do.	1961	Drl	102	2	--	do.	1,265	r6	8/16/61	--	--	T, De	Log; principal water-bearing zone from 8 to 13 ft below LS.
214-901-1	U.S. Geological Survey	1961	Aug	74	3	--	Sand and gravel	1,300	e10	6/28/61	--	--	T, De	Log.
-2	G. Grover	--	Drl	31	6	--	do.	1,300	5.5	9/ 6/61	Sw	200	D	
-3	R. Payne	1958	Drv	r20	1 1/4	--	do.	1,290	r5	--	Sw	100	D	Finished with screened drive point.
-4	N. Tarr	--	Drv	r18	1 1/4	--	do.	1,295	r10	--	Sw	200	D	Anal; finished with screened drive point.
-6	F. Frank	--	Drv	r20	1 1/2	--	do.	1,300	--	--	Sw	100	D	Finished with screened drive point.
214-902-1	E. Raymond	--	Drl	r170	4	--	Gravel	1,270	+6.5	8/24/61	Sw	400	D, F	Anal; temp 54.0 8/24/61; H_2S; inadequate during heavy use; flows less than 1 gpm at 1.0 ft above LS.
-2	D. Morrison	--	Dug	8	48	--	Sand	1,280	0.1	8/30/61	--	--	F	
-3	E. Wheeler	--	Drv	r18	1 1/4	--	Sand and gravel	1,290	r5	--	Sw	500	D, C	Finished with screened drive point.
-4	M. Philips	--	Drv	r12	1 1/4	--	do.	1,280	r5	--	Sw	500	D, F	Do.
214-903-1	B. Kelsey	1885	Drl	r314	3, 2	--	Gravel	1,270	e+8	8/ 9/61	--	--	D, F	Log; anal.
-2	A. Cole	1955	Drl	r60	6	--	do.	1,300	--	--	Sw	100	D	H_2S; inadequate in summers.
-3	B. Clark	--	Drl	r80	6	--	Sand and gravel	1,300	--	--	Dw	200	D	H_2S.
-4	G. Leach	--	Drv	r80	2	--	do.	1,280	e+2.3	9/ 7/61	--	--	A	Temp 50.0 9/7/61; H_2S; flows less than 1 gpm at 2.0 ft above LS.
-5	F. Dye	--	Drv	r44	1 1/4	--	do.	1,290	--	--	Sw	150	D	Finished with screened drive point.
-6	P. Bernard	1938	Drv	r22	1 1/4	--	Sand	1,280	1.0	9/11/61	Sw	100	D	Temp 49.0 9/11/61; H_2S; inadequate in summers; flows less than 1 gpm at 2.0 ft below LS; finished with screened drive point.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
214-903-7	E. Bentley	--	Drl	r85	4	--	Gravel	1,280	+2.4	9/11/61	Sw	100	D	Anal; temp 50.0 9/11/61; H_2S; flows 15 gpm at 0.7 ft above LS.
-8	F. Chadwick	1961	Drl	r362	8, 6	--	do.	1,270	+10.0	10/27/61	--	800	D, F	Log; anal; temp 55.0 10/27/61; flows 85+ gpm at 1.0 ft above LS.
-9	Conewango Valley Mills	1961	Drl	92	6	--	do.	1,280	p0.0	10/27/61	--	--	I	Log; temp 52.0 10/27/61; H_2S; yield 150 gpm with 9.0 ft of dd; to be used for fire protection.
214-904-1	F. Brown	1950	Dug	10	24	--	Sand and gravel	1,320	3.7	8/30/61	--	250	D	Gravity feed to house.
214-916-1	U.S. Geological Survey	1961	Aug	55	3	--	do.	1,305	8.0	7/11/61	--	--	T, De	Log; principal water-bearing zone from 9 to 45 ft below LS.
-2	H. Malloy	--	D.I	r100	6	--	Gravel	1,290	+2.3	6/29/62	--	1,000	F	Temp 50.5 6/29/62; flows 1 gpm at 0.5 ft above LS.
-3	do.	--	Drl	r100	6	--	Sand and gravel	1,290	+3.0	6/29/62	--	2,000	F	Temp 48.5 6/29/62: flows 1 1/2 gpm at 2.0 ft above LS.
-4	do.	--	Drl	r100	6	--	do.	1,290	flows	--	Sw	500	D	
-5	do.	--	Drl	r56	6	--	do.	1,290	flows	--	Sw	200	D	
214-918-1	C. Tilyou	a1940	Drv	r40	1 1/4	--	Gravel	1,295	--	--	Sw	880	F	Finished with screened drive point.
-2	do.	a1940	Drv	22	1 1/4	--	do.	1,295	15.6	9/23/60	--	--	A	Do.
-3	M. Abersold	1958	Drv	?	1 1/4	--	Sand	1,290	--	--	Sw	250	D	Do.
-4	C. Seagren	1952	Drl	r35	6	--	Gravel	1,275	r6	1952	Sw	150	D	
-5	G. Crandall	1952	Drl	r40	7	r7	Bedrock	1,280	--	--	--	100	D	Log; csg 8 ft.
-6	E. Tilyou	b1945	Drl	r180	--	?	do.	1,305	--	--	Sw	200	D	
-8	A. Allenbrand	--	Dug	5	24	--	Sand and gravel	1,270	1.4	11/11/60	--	--	D	
-9	U.S. Geological Survey	1961	Aug	132	3	--	Silt	1,260	--	--	--	--	T, De	Log.
-10	do.	1961	Aug	122	3	--	Sand and gravel	1,255	5.0	7/21/61	--	--	T, De	Do.
214-926-1	D. Beebe	a1940	Drv	r110	1 1/4	--	do.	1,320	flows	1/18/63	Sw	100	D	Finished with screened drive point.
-2	Dewittville Grange	--	Drv	r110	1 1/4	--	do.	1,320	flows	1/18/63	Sw M	--	In	Water level greater than 3.0 ft above LS; finished with screened drive point.
-3	Chautauqua County Home	--	Drl	r188	7	--	Gravel	1,340	(r)flows	--	--	--	A	
214-930-1	Village of Mayville	1954	Drl	r26	8	--	do.	1,320	e3	9/28/62	Dw	0	PS	Log; yield 250 gpm (r); screened from 21 to 26 ft below LS; standby use only.
-2	do.	--	Dug	r26	8(ft)	--	do.	1,320	e5	9/28/62	Dw	250,000	PS	Log; anal; pt; yield 350 gpm with 13.0 ft of dd; screened from 21 to 26 ft below LS.
-3	do.	--	Drv	24	3 1/2	--	Sand and gravel	1,325	5.2	9/28/62	--	--	0	Flows in spring (r).
-4	U.S. Geological Survey	1962	Jet	23	1 1/4	--	do.	1,320	6.8	11/28/62	--	--	0	Log.
215-901-1	R. and J. Walin	--	Dug	11	24	--	do.	1,370	6.9	9/21/61	Sw M	40	D	H_2S.
-2	do.	--	Drl	r125	6	--	do.	1,370	--	--	Dw	--	U	
215-902-1	C. Wickmark	1961	Drl	249	7	--	Sand	1,280	4.0	6/ 1/61	--	--	U	Log; yield 1 gpm with 14.0 ft of dd; well deepened to 504 ft below LS during Sept. 1961 (r).
-2	do.	1961	Drl	r583	7	--	do.	1,280	--	--	--	--	De	Log; driller reports hitting a large tree log at 583 ft below LS which halted drilling.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
215-902-3	C. Wickmark	1907	Jet	359	2	--	Sand and gravel	1,280	+0.1	9/27/61	--	--	A	Well was used until 1960 when it became inadequate.
215-904-1	S. Kanney	--	Drv	r17	1 1/4	--	do.	1,300	r9	--	Sw M	--	U	Inadequate in 1960; finished with screened drive point.
215-915-1	A. Peck	1955	Drl	r100	--	r41	Bedrock	1,365	--	--	--	--	T, De	
-2	T. Anderson	1955	Drl	r154	--	r32	do.	1,340	--	--	--	--	T, De	Yield 10 gpm (b).
-3	J. Betts	1955	Drl	r72	--	r69	do.	1,375	--	--	--	--	T, De	
-5	G. Thelender	1955	Drl	r140	--	r44	do.	1,360	--	--	--	--	T, De	
215-916-1	J. Anderson	a1920	Drl	74	5	--	Gravel	1,335	14.2	9/ 2/60	--	--	A	
-2	Cassadaga Valley Central School	--	Drl	r118	8	?	Bedrock	1,310	--	--	Dw	7,000	In	Anal.
-3	Village of Sinclairville	1956	Drl	56	12, 8	--	Sand end gravel	1,330	8.8	7/17/56	Dw	--	PS	Log; anal; yield 150 gpm with 1.6 ft of dd; screened from 51 to 56 ft below LS.
-5	Eldon Lawson	--	Drv	r26	1 1/4	--	Sand	1,320	--	--	Sw	200	D	
-6	U.S. Geological Survey	1961	Aug	56	3	50	Sand and gravel	1,325	16.7	7/20/61	--	--	T, De	Log; principal water-bearing zone from 17 to 50 ft below LS.
-7	N.Y.S. Dept. Pub. Wks.	1959	Orl	28	2	r16	Bedrock	s1,354.5	r7.2	5/ 7/59	--	--	T, De	Log.
-8	do.	1959	Drl	20	2	r14	Sand and gravel	s1,352.8	r4.5	5/ 8/59	--	--	T, De	Log; principal water-bearing zone from 10 to 14 ft below LS.
215-917-1	R. Johnson	--	Drv	20	1 1/4	--	Sand	1,330	4.4	12/ 7/60	Sw M	--	U	Finished with screened drive point.
215-918-1	G. Millwerd	1957	Dug	11	24	--	do.	1,260	5.0	11/11/60	Sw	640	D, F	
-2	G. Jorgensen	a1900	Dug	12	30	--	do.	1,270	9.8	9/23/60	Sw	350	D	
-3	C. Polen	--	Dug	9	24	--	do.	1,275	5.2	11/11/60	--	--	D	
215-919-1	E. and G. Gibbons	1957	Drl	r105	5	--	Gravel	1,280	flows	8/18/60	Sw	150	D	Anal; temp 48.2 8/18/60; yield 100 gpm (r); flows 15 gpm at LS.
215-920-1	R. Runge	1955	Drl	r104	6	--	do.	1,285	+3.4	11/17/60	Sw	150	D	Log; anal; temp 49.0 10/17/60.
-2	W. and E. Stewart	1950	Drl	r50	6	r26	Bedrock	1,330	--	--	Dw	800	D, F	Log; iron.
-3	O. Carlson	e1900	Drl	36	6	--	Gravel	1,335	17.7	12/ 7/60	--	--	A	
215-928-1	Hartfield Fire Dept.	--	Jet	r153	2	--	Sand and gravel	1,315	flows	9/19/60	--	--	PS	Log; anal; temp 49.5 9/19/60; water greater than +2.5 ft above LS; flows 2 gpm at 2.5 ft above LS.
-2	R. Anderson	1952	Dug	12	30	--	Gravel	1,320	6.2	12/ 5/62	Sw	350	D	
-3	S. Wojcinski	1954	Jet	r143	1 1/4	--	do.	1,320	flows	12/ 5/62	Sw	250	D	Flows less than 1 gpm at 1.2 ft above LS.
-4	L. Wilson	1953	Drl	r164	6	--	do.	1,315	0.1	12/ 5/62	Sw	w200 s1,200	C	Log; yield 70 gpm (r); flowed less than 1 gpm when drilled (r).
216-901-1	GLF Petroleum Corp.	1950	Drl	r66	7	--	do.	1,320	--	--	Dw	300	D, I	Log; H_2S; iron.
216-902-1	U.S. Geological Survey	1961	Aug	94	3	--	Sand and gravel	1,305	--	--	--	--	T, De	Log.
216-905-1	M. Quaintince	1931	Drv	r17	1 1/4	--	Gravel	1,330	r6	--	Sw M	0	U	Finished with screened drive point.
-2	do.	1931	Drv	r21	1 1/4	--	do.	1,330	r6	--	Sw	150	D	Do.
-3	R. Babcock	--	Drv	r20	1 1/4	--	do.	1,320	r8	--	Sw	200	D	Do.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupent	Year completed	Type of well	Depth of well (feet)	Diamater (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
216-917-1	E. Witt	a1900	Drl	40	6	--	Sand	1,320	p20.5	10/28/60	Dw	1,200	F	Anal.
-2	F. Torgeson	--	Drl	r70	5	r20	Bedrock	1,325	--	--	Sw	--	D	Yield 5 gpm (r); csg 20 ft.
-3	W. Beckman	a1956	Drl	r64	7	r20	do.	1,335	--	--	Dw	150	D	Csg 20 ft.
216-918-1	W. Shepardson	a1942	Dug	10	30	--	Gravel	1,285	5.8	9/28/60	Sw	s150 w450	D, F	Log.
-2	K. Snyder	1955	Oug	r20	36	--	Sand and gravel	1,290	--	--	Sw M	--	D	Unused in winter.
-3	K. Terrill	1950	Drv	r38	1 1/4	--	Sand	1,280	--	--	Sw	150	D	Inadequate during heavy use; finished with screened well point.
-4	do.	1960	Drv	r18	1 1/4	--	do.	1,280	r2	6/ 5/61	Sw M	20	D	Log; finished with screened well point.
-5	T. Roberts	--	Dug	5	36	--	do.	1,280	3.5	6/ 5/61	Sw	250	D	Iron.
-6	U.S. Geological Survey	1961	Aug	132	3	--	do.	1,280	5.0	6/29/61	--	--	T, De	Log.
216-919-2	G. Bridenbaker	--	Drv	r20	1 1/4	--	Sand and gravel	1,280	--	--	Sw	150	D	Finished with screened drive point.
216-921-1	C. McIntyre	1946	Drv	r19	1 1/4	--	Sand	1,295	--	--	Sw	200	D	Do.
-2	L. Barber	b1900	Dug	10	36	--	do.	1,295	9.2	10/11/60	Sw	100	D	Inadequate.
-3	do.	1955	Drv	14	2	--	do.	1,295	10.6	10/11/60	--	--	A	Finished with screened drive point.
-4	do.	--	Drv	8	1 1/4	--	do.	1,295	6.7	10/11/60	--	--	A	Do.
-5	A. Vandottie	a1922	Drl	r120	6	r120	Bedrock	1,290	1.1	11/14/60	Sw	750	D, S	Anal; temp 50.0 11/14/60; H_2S; inadequate; yield 5 gpm (r); csg 120 ft.
217-905-1	Village of Cherry Creek	--	Orv	r50	2	--	Gravel	1,300	flows	7/ 5/61	--	--	PS	Temp 54.0 7/5/61; water level is greater than 2.9 ft above LS; flows greater than 1/2 gpm at 2.8 ft above LS.
-2	C. Frost	--	Drl	r95	4	--	do.	1,290	+9.1	7/ 6/61	--	--	D	Anal; temp 51.0 7/6/61; flows 2.7 gpm at 2.3 ft above LS.
-3	L. Rootenbear	--	Drl	r180	4	--	do.	1,285	flows	8/ 9/61	--	--	A	Temp 52.0 8/9/61; flows less than 1 gpm at LS; well appears partially plugged.
-4	Village of Cherry Creek	--	Drv	r70	1 1/4	--	do.	1,295	+2.5	8/ 9/61	--	1,440	F	Anal; temp 50.5 8/9/61; flows 1 gpm at 1.0 ft above LS.
217-906-1	J. Roloff	b1900	Drv	r63	3	--	do.	1,315	+7.9	7/ 5/61	--	50	D	Log; anal; temp 53.0 7/5/61; flows 4 gpm at 2.9 ft above LS.
-2	Village of Cherry Creek	1931	Drl	r55	6	--	do.	1,345	(r)flows	--	Dw	--	PS	Yield 100 gpm (r); used as standby well only.
-4	C. Madison	--	Drv	r36	1 1/4	--	do.	1,300	+10.0	7/ 6/61	--	--	C	Anal; temp 50.0 7/6/61; flows 3 gpm at 3.3 ft above LS; used for cooling.
-5	J. Schweiger	--	Drv	r60	1 1/4	--	do.	1,305	+8.5	7/ 6/61	--	--	D	Log; temp 52.0 7/6/61; flows 17 gpm at 2.0 ft above LS.
217-917-1	J. Smith	a1952	Drl	r60	6	--	Sand	1,340	--	--	Dw	830	D, F	
-2	F. Issler	--	Drv	r35	1 1/4	--	do.	1,320	--	--	Sw	350	D	
-3	C. Weatherford	1957	Drl	37	6	?	Sand, bedrock	1,300	3.2	12/ 7/60	Dw	500	D, C	H_2S; yield 12 gpm (b); driller reports well is 66 ft deep, may have been filled with overlying sand.
217-918-1	H. Lehnen	a1945	Drl	r252	6	--	Sand	1,285	r+14	1945	Sw	150	D	Anal; temp 49.0 10/15/60; flows intermittently.
-2	L. Love	--	Dug	10	1 1/4	--	do.	1,290	5.9	11/15/60	--	--	A	Inadequate; originally dug well; 1 1/4 pipe was installed and well filled.
-3	do.	1960	Drl	r305	6	--	Gravel	1,290	(r)flows	--	--	--	D, F	Log.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
217-919-1	A. Woodard	1959	Dug	r8	12(ft)	--	Sand	1,290	r5	8/18/60	Sw	2,100	D, F	Log.
-3	C. Erbin	--	Drv	r32	1 1/4	--	Sand and gravel	1,315	--	--	Sw	100	D	Inadequate during 1960; finished with a screened drive point.
217-921-1	J. Woodward	a1910	Drv	r14	1 1/4	--	Sand	1,290	--	--	Sw	150	D	Finished with screened drive point.
-2	do.	a1910	Drv	14	1 1/4	--	do.	1,290	3.7	10/11/60	--	--	A	Do.
-3	W. O'Brien	a1950	Drl	63	6	a20	Bedrock	1,290	3.3	10/15/60	Sw M	50	D	Anal; temp 49.0 10/15/60; csg 24 ft.
-4	U.S. Geological Survey	1961	Aug	107	3	--	Silt, sand and gravel	1,290	2.3	7/11/61	--	--	T, De	Log; principal water-bearing zone from 7 to 22 ft below LS.
-5	G. Anderson	--	Drl	a100	6	?	Bedrock	1,320	--	--	Sw M	--	U	H_2S; occupant reports "mineral" taste.
217-922-1	D. Worden	a1900	Drl	r68	6	?	do.	1,330	--	--	Dw	1,050	F	Anal; H_2S.
218-917-1	B. Nichols	--	Drl	57	6	?	do.	1,365	50.7	9/28/60	Dw	400	D	
-2	do.	e1945	Drl	r110	6	r25	do.	1,330	r50	--	Dw	690	D, F	Anal; yield 25 gpm (r); csg 26 ft.
-3	U.S. Geological Survey	1961	Aug	142	3	--	Clay, gravel, sand	1,300	4.0	7/10/61	--	--	T, De	Log; principal water-bearing zone from 2 to 19 ft below LS.
218-918-1	F. Luce	a1942	Drv	13	1 1/4	--	Sand	1,305	7.4	9/28/60	--	--	A	Finished with screened drive point.
218-921-1	C. Higgs	a1910	Dug	r25	r24	--	do.	1,300	--	--	Sw	500	D	
-2	M. Kelley	1956	Drl	r32	6	--	Gravel	1,310	r12	7/ /56	Sw	150	D	Log.
-3	M. Piersons	1913	Drv	r18	1 1/4	--	Sand	1,310	--	--	Sw	90	F	Finished with screened drive point.
-4	M. Kelley	1955	Dug	23	4, 18	--	Sand and gravel	1,310	18.0	10/15/60	--	--	A	Water never would clear.
-5	W. Witcher	--	Drl	166	6, 4	?	Bedrock	1,300	+0.3	6/12/61	--	--	A	Anal; temp 52.0 6/12/61; gas (?); iron; flows less than 1 gpm at 0.2 ft above LS.
-6	A. Briggs	--	Drv	r31	1 1/4	--	Sand	1,320	r10	--	Sw	200	D	Yield 5 gpm (r); finished with screened drive point.
-7	W. Putnam	1951	Drv	r16	1 1/4	--	Gravel	1,300	r10	--	Sw	100	D	Finished with screened drive point.
-8	Chautauqua County Fireman's Frat., Inc.	1961	Drv	r28	1 1/4	--	Sand	1,300	--	--	Sw M	0	U	Yield less than 1 gpm (e); finished with screened drive point; if yield does not increase, well will be destroyed.
-9	U.S. Geological Survey	1961	Aug	102	3	--	do.	1,300	9.0	6/27/61	--	--	T, De	Log; principal water-bearing zone from 7 to 57 ft below LS.
218-922-1	E. Howard	1954	Drv	r14	1 1/4	--	Sand and gravel	1,310	rDry	11/ 7/60	Sw	--	F	Inadequate; finished with screened drive point.
219-911-1	N.Y.S. Conservation Dept.	--	Dug	14	36	--	Till	2,065	F4.7	7/ 5/50	--	--	U	Partial record of water-level observations from 1950-56.
219-917-2	J. Smith	1953	Drl	r78	r5	--	Sand	1,335	--	--	Sw	600	C	
-3	U.S. Geological Survey	1961	Aug	102	3	--	Sand and gravel	1,320	6.3	7/10/61	--	--	T, De	Log; principal water-bearing zone from 12 to 80 ft below LS.
219-921-1	Cassadaga Valley Central School System	1950	Drl	r28	6	--	do.	1,315	r6	12/12/50	Dw	2,000	In	Log; yield 75 gpm with 13 ft of dd; screened from 23.0 to 28.1 ft below LS.
-2	F. Baker	1944	Drv	r15	1 1/4	--	Sand	1,310	--	--	Sw	350	D	Finished with screened drive point.
-3	H. Storer	1949	Drl	70	5	?	Bedrock	1,350	31.8	11/17/60	Dw	150	D	
-4	S. Carlson	--	Drv	r28	1 1/4	--	Sand	1,320	--	--	Sw	300	D	Anal; temp 50.0 6/12/61; yield 10 gpm (r); finished with screened drive point.

Table 6.--Records of selected wells and test holes in the Jamestown area (Continued)

Well number	Owner or occupant	Year completed	Type of well	Depth of well (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing materials	Altitude above sea level (feet)	Water level: Below land surface (feet)	Water level: Date	Method of lift	Estimated pumpage (gallons per day)	Use	Remarks
219-921-5	E. Marsh	--	Drv	r26	1 1/4	--	Gravel	1,300	r4	--	Sw	150	D	H_2S?; finished with screened drive point.
-6	C. Cobb	--	Drv	r22	1 1/4	--	Sand and gravel	1,310	--	--	Sw	100	D	Anal; finished with screened drive point.
219-922-1	J. Beardsley	--	Dri	70	4	--	Gravel	1,325	6.9	11/17/60	Sw	800	F	Flows in spring (r).
-2	R. Gilson	--	Drv	r21	1 1/2	--	Sand	1,315	r3	--	Sw	300	F	Finished with screened drive point.
220-919-1	Village of Cassadaga	1958	Dug	r20	12	--	Sand and gravel	1,310	r7	9/ 6/60	Dw	70,000	PS	Log; yield 220 gpm; screened.
-2	do.	1958	Dug	r19	12	--	do.	1,310	r7	8/22/60	Dw	70,000	PS	Anal; pt; temp 53.0 9/6/60; yield 190 gpm; screened.
-4	do.	1962	Dug, Jet	18	42	--	do.	1,310	2.5	12/ 6/62	--	--	U	Log; may be put into use at future date.
-5	U.S. Geological Survey	1962	Jet	16	1 1/4	--	do.	1,310	3.7	12/ 6/62	--	--	O	Log.
220-922-2	E. Mesiker	1960	Drv	r24	2	--	Gravel	1,330	0.0	9/30/60	--	--	U	Anal; temp 50.0 9/30/60; flows 10 gpm at 5.9 ft below LS.
-3	do.	1957	Dri	r54	6	--	do.	1,320	+10.0	10/17/60	--	--	D	Anal; temp 51.0 10/17/60; flows 30 gpm at 3.0 ft above LS; used during summer only.
-4	C. Case	1960	Dri	37	5	r8	Bedrock	1,340	15.2	9/26/60	--	--	U	Log.
-5	R. and E. Kelly	1902	Dri	r50	6	--	Gravel	1,350	--	--	Sw	200	D	Anal; temp 50.0 10/27/60; H_2S; flows in spring (r).
-6	do.	a1918	Dri	50	6	--	do.	1,350	3.7	10/27/60	Sw	60	F	H_2S; used summers only; flows in spring (r).
-7	E. Mesiker	--	Dri	35	6	--	do.	1,340	6.6	12/ 8/60	Sw	100	D	
-9	U.S. Geological Survey	1961	Aug	142	3	--	Sand	1,330	e10	6/27/61	--	--	T, De	Log; principal water-bearing zone is from 7 to 132 ft below LS.
-10	N.Y.S. Dept. Pub. Wks.	1961	Dri	102	2	--	do.	s1,320.2	r6.2	9/26/61	--	--	T, De	Log.
-11	do.	1961	Dri	52	2	--	do.	s1,320.0	r8.0	9/26/61	--	--	T, De	Do.
220-923-1	J. Beardsley	--	Dri	r40	6	--	Gravel	1,325	10.2	9/14/60	Sw M	--	D	Anal; temp 49.0 9/14/60; yield 6 gpm (r).
-2	F. Yonkers	--	Dri	r90	6	?	Bedrock	1,330	--	--	Dw	380	D, F	Anal; iron.
221-918-1	G. Brown	a1937	Dri	86	6	--	Gravel	1,280	22.2	8/30/60	Dw	250	D	Anal; H_2S; iron.
-2	A. Longhouse	1960	Dri	39	6	--	do.	1,320	15.5	8/30/60	Dw	--	U	Yield 30 gpm (b).
-3	O. Ulrich	1959	Dri	39	5	--	Sand and gravel	1,330	14.4	11/ 7/60	--	--	A	Yield 20 gpm (b).
221-919-1	L. Straight	a1948	Dri	49	6	--	do.	1,315	6.4	8/30/60	Sw	--	D	Anal.
-2	Lily Dale Assembly	a1920	Dri	r84	8	--	do.	1,335	--	--	Sw M	--	U	Yield 50 gpm (r).
-3	Y. M. C. A.	--	Dri	36	6	--	do.	1,330	26.4	11/ 7/60	Sw	--	In	Anal; used during summer only.
221-923-1	R. Birmingham	--	Dri	r120	--	?	Bedrock	1,320	+6.9	11/17/60	--	--	D	Anal; temp 49.0 10/17/60; flows 5 gpm at LS.
222-919-1	Girl Scouts of America	--	Dri	r314	7	--	Gravel	1,300	--	--	--	--	In	Used during summers.

Table 7.--Records of selected springs in the Jamestown area

Spring number: See "Well-Numbering System" in text for explanation.

Altitude above sea level: Altitudes estimated from topographic maps to nearest 5 feet.

Yield: e - estimated
- less than
- greater than
gpm - gallons per minute

Use: D - domestic
F - farm
PS - public supply
U - unused

Remarks: Anal - chemical analysis given in this report.

Spring number	Owner	Topographic situation	Water-bearing material	Altitude above sea level (feet)	Yield (gallons per minute)	Temperature (°F)	Date of yield and temperature measurement	Use	Remarks
201-917-4Sp	J. Howard	Hillside	Till	1,350	2	--	6/ 8/61	D	Enclosed by concrete curb, maximum depth of which is 0.8 ft below LS.
207-905-2Sp	A. Willis	Valley bottom	Sand and gravel	1,260	1	51.0	9/25/61	D	Enclosed by concrete curb, maximum depth of which is 1.2 ft below LS; water-bearing material overlies silt and clay; supplies two families.
207-906-2Sp	H. Robbins	do.	do.	1,260	e5	52.0	8/23/61	D, F	Reservoir is wooden barrel; maximum depth is 3.0 ft below LS; supplies two families.
209-903-1Sp	D. Beaver	Slope of terrace about 25 ft from stream bottom	do.	1,340	e 60	47.5	8/25/61	D, F	Anal; several springs developed with small interconnected concrete reservoirs about 1.0 ft deep; numerous seeps on slope; formerly used by soft drink bottling company.
209-906-2Sp	North Side Water Co.	Hillside	Till (at bedrock contact)	1,400	--	--	--	D, PS	Supplies 14 families.
210-906-1Sp	C. and E. Abers	do.	do.	1,410	1	--	8/17/60	F	Developed with shallow-tiled shaft.
211-915-12Sp	G. Howard	Valley bottom	Sand and gravel	1,260	56	--	11/28/60	F	Flow of several springs and seeps impounded by small concrete dam; water-bearing material overlies silt and clay.
211-915-14Sp	N. Johnson	do.	do.	1,265	0	53.5	11/ 7/60	U	Anal; small pond impounded by earthen dam; water-bearing material overlies silt and clay.
211-927-6Sp	N.Y.S. Dept. Pub. Wks.	Valley bottom (in streambed)	do.	1,310	e 60	48.0	6/ 5/63	U	Four large springs in streambed at base of bridge abutments; water-bearing material is confined at a depth of 25 to 30 ft below LS by silt and clay; construction of bridge allowed discharge.
212-900-1Sp	J. Fischer	Hillside	do.	1,310	1	47.0	9/ 7/61	D, F	Developed with tile 18 inches in diameter, maximum depth is 1.7 ft below LS.
-2Sp	M. Howand	do.	do.	1,320	1	49.0	9/ 7/61	D, F	Developed with tile 18 inches in diameter, maximum depth is 1.5 ft below LS.

Table 7.--Records of selected springs in the Jamestown area (Continued)

Spring number	Owner	Topographic situation	Water-bearing material	Altitude above sea level (feet)	Yield (gallons per minute)	Temperature (°F)	Date of yield and temperature measurement	Use	Remarks
212-917-5Sp	R. Reardon	Valley bottom	Sand	1,280	--	--	--	F	Undeveloped.
214-901-5Sp	N.Y.S. Dept. Pub. Wks.	Hillside	Sand and gravel	1,300	1 1/2	59.0	9/ 6/61	PS	Shallow concrete shaft in water-bearing material; supplies drinking fountain.
216-902-2Sp	G. Ennis	do.	do.	1,330	--	--	--	D, F	Developed with concrete shaft to a maximum depth of 3.5 ft below LS.
217-908-1Sp	Village of Cherry Creek	Near small stream at base of steep slope	Till (at bedrock contact)	1,600	e 60	52.0	7/ 5/61	PS	Seven springs developed with concrete reservoirs and all feeding to main reservoir; water-bearing material overlies shale bedrock. Estimated use is 90,000 gpd.
217-913-1Sp	Village of Sinclairville	Hillside	Till	1,580	r 22	--	--	PS	Several springs developed; water-bearing zone overlies shale bedrock; estimated use is 30,000 gpd.
217-919-2Sp	J. Titus	Valley bottom	Sand	1,300	--	57.0	8/18/60	U	Anal; undeveloped.
220-922-8Sp	C. Campbell	Hillside	Till (at bedrock contact)	1,370	1 1/2	--	6/ 6/61	D, F	Spring has been deepened and developed.
220-923-3Sp	H. Howard	do.	Sand	1,370	--	--	--	D	Developed with concrete reservoir 2.3 ft in depth.

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An asterisk (*) indicates that the report is out of print, but such reports are available for consultation in certain libraries.

BULLETINS:

*GW- 1 WITHDRAWAL OF GROUND WATER ON LONG ISLAND, N. Y.
D. G. Thompson and R. M. Leggette (1936)

*GW- 2 ENGINEERING REPORT ON THE WATER SUPPLIES OF LONG ISLAND.
Russell Suter (1937)

*GW- 3 RECORD OF WELLS IN KINGS COUNTY, N. Y.
R. M. Leggette and others (1937)

*GW- 4 RECORD OF WELLS IN SUFFOLK COUNTY, N. Y.
R. M. Leggette and others (1938)

*GW- 5 RECORD OF WELLS IN NASSAU COUNTY, N. Y.
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*GW- 6 RECORD OF WELLS IN QUEENS COUNTY, N. Y.
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*GW- 7 REPORT ON THE GEOLOGY AND HYDROLOGY OF KINGS AND QUEENS COUNTIES, LONG ISLAND.
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GW- 8 RECORD OF WELLS IN KINGS COUNTY, N. Y., SUPPLEMENT 1.
R. M. Leggette and M. L. Brashears, Jr. (1944)

GW- 9 RECORD OF WELLS IN SUFFOLK COUNTY, N. Y., SUPPLEMENT 1.
C. M. Roberts and M. L. Brashears, Jr. (1945)

GW-10 RECORD OF WELLS IN NASSAU COUNTY, N. Y., SUPPLEMENT 1.
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C. M. Roberts and M. C. Jaster (1947)

*GW-12 THE WATER TABLE IN THE WESTERN AND CENTRAL PARTS OF LONG ISLAND, N. Y.
C. E. Jacob (1945)

*GW-13 THE CONFIGURATION OF THE ROCK FLOOR IN WESTERN LONG ISLAND, N. Y.
Wallace de Laguna and M. L. Brashears, Jr. (1948)

GW-14 CORRELATION OF GROUND-WATER LEVELS AND PRECIPITATION ON LONG ISLAND, N. Y.
C. E. Jacob (1945)

*GW-15 PROGRESS REPORT ON GROUND-WATER RESOURCES OF THE SOUTHWESTERN PART OF BROOME COUNTY, N. Y.
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*GW-16 PROGRESS REPORT ON GROUND-WATER CONDITIONS IN THE CORTLAND QUADRANGLE, N. Y.
E. S. Asselstine (1946)

*GW-17 GEOLOGIC CORRELATION OF LOGS OF WELLS IN KINGS COUNTY, N. Y.
Wallace de Laguna (1948)

GW-18 MAPPING OF GEOLOGIC FORMATIONS AND AQUIFERS OF LONG ISLAND, N. Y.
Russell Suter, Wallace de Laguna, and N. M. Perlmutter (1949)

*GW-19 GEOLOGIC ATLAS OF LONG ISLAND. (Consists of large-scale reproductions of maps in GW-18.) (1950)

*GW-20 THE GROUND-WATER RESOURCES OF ALBANY COUNTY, N. Y.
Theodore Arnow (1949)

GW-20A BURIED PREGLACIAL GROUND-WATER CHANNELS IN THE ALBANY-SCHENECTADY AREA IN NEW YORK.
E. S. Simpson (1949)

GW-21 THE GROUND-WATER RESOURCES OF RENSSELAER COUNTY, N. Y.
R. V. Cushman (1950)

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BULLETINS:

GW-22 THE GROUND-WATER RESOURCES OF SCHOHARIE COUNTY, N. Y.
J. M. Berdan (1950)

GW-23 THE GROUND-WATER RESOURCES OF MONTGOMERY COUNTY, N. Y.
R. M. Jeffords (1950)

GW-24 THE GROUND-WATER RESOURCES OF FULTON COUNTY, N. Y.
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*GW-27 THE WATER TABLE IN LONG ISLAND, N. Y., IN JANUARY 1951.
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GW-31 RECORDS OF WELLS IN SUFFOLK COUNTY, N. Y., SUPPLEMENT 2.
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GW-32 GROUND WATER IN BRONX, NEW YORK, AND RICHMOND COUNTIES WITH SUMMARY DATA ON KINGS AND QUEENS COUNTIES, NEW YORK CITY, N. Y.
N. M. Perlmutter and Theodore Arnow (1953)

GW-33 THE GROUND-WATER RESOURCES OF WASHINGTON COUNTY, N. Y.
R. V. Cushman (1953)

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